DOCUMENT RESUME

ED 325 682 CE 056 263

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TITLE	Engine Performance (Section B: Fuel and Exhaust Systems). Auto Mechanics Curriculum Guide. Module 3. Instructor's Guide.
INSTITUTION	Missouri Univ., Columbia. Instructional Materials Lab.
SPONS AGENCY	Missouri State Dept. of Elementary and Secondary Education, Jefferson City. Div. of Vocational and Adult Education.
PUB DATE	Jul 90
NOTE	263p.; For related modules, see ED 317 715-716, ED 317 839, and CE 056 262-266.
AVAILABLE FROM	Instructional Materials Laboratory, University of Missouri, 2316 Industrial Drive, Columbia, MO 65202 (Order No. 70-183B-I: $15.00).
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	*Auto Mechanics; Behavioral Objectives; *Engines; *Fuels; *Industrial Arts; Learning Activities; Motor Vehicles; Secondary Education; State Curriculum Guides
IDENTIFIERS	*Automotive Exhaust Systems; *Automotive Fuel Systems; Missouri

ABSTRACT

This module is the third of nine modules in the competency-based Missouri Auto Mechanics Curriculum Guide. Six units cover: fuel supply systems; carburetion; carburetor service; gasoline engine electronic fuel injection; diesel fuel injection; and exhaust systems and turbochargers. Introductory materials include a competency profile and cross-reference table that shows how competencies relate to instructional objectives, job sheets, assignment sheets, and test items. Each unit consists of some or all of these components: objective sheet with unit and specific objectives; cover sheet with content outline and list of references; information sheets; assignment sheets; job sheets; and unit test with answer key. (YLB)

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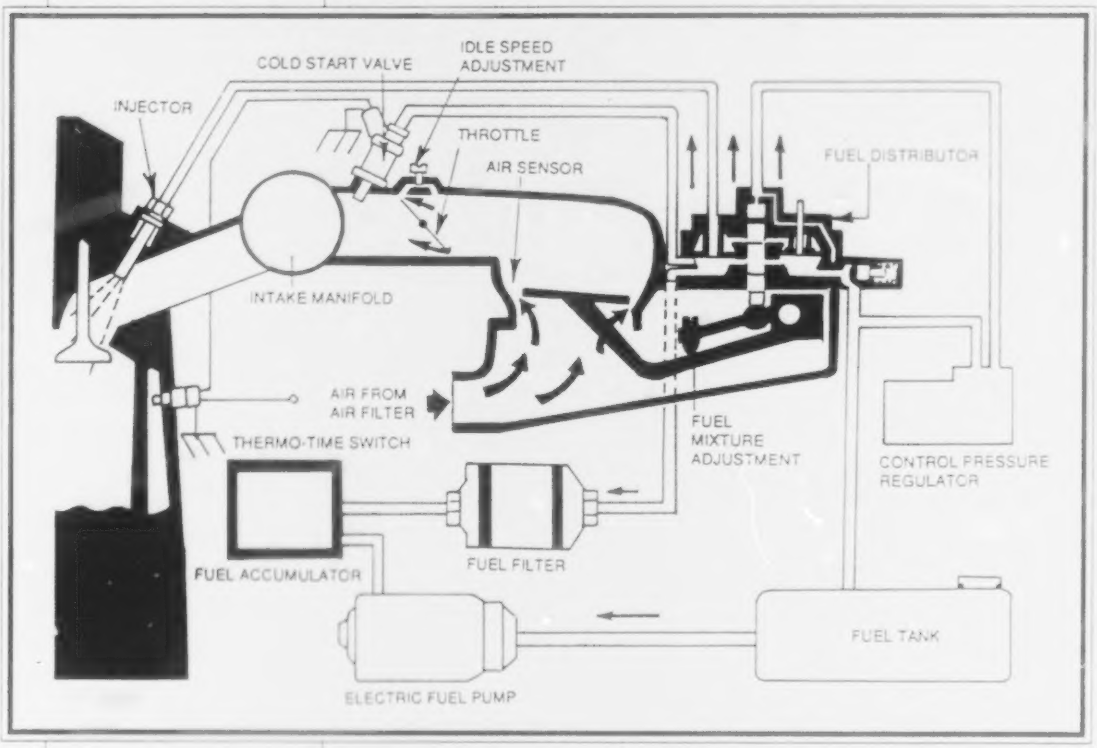
70-183B-I
Instructor's Guide

Auto Mechanics

Curriculum Guide


IDLE SPEED
ADJUSTMENT
COLD START VALVE
INJECTOR
THROTTLE
AIR SENSOR
FUEL DISTRIBUTOR
INTAKE MANIFOLD
AIR FROM
AIR FILTER
THERMO-TIME SWITCH
FUEL
MIXTURE
ADJUSTMENT
CONTROL PRESSURE
REGULATOR
FUEL ACCUMULATOR
FUEL FILTER
FUEL TANK
ELECTRIC FUEL PUMP

Module 3

Engine Performance (Section B: Fuel and Exhaust Systems

Produced by
Instructional Materials Laboratory
In cooperation with the Dept. of
Elementary and Secondary
Education

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MODULES INCLUDED IN THE AUTO MECHANICS CURRICULUM GUIDE

INTRODUCTION TO AUTO MECHANICS
ELECTRICAL SYSTEMS
ENGINE PERFORMANCE
ENGINE REPAIR
SUSPENSION AND STEERING
BRAKES
MANUAL DRIVE TRAIN AND AXLES
AUTOMATIC TRANSMISSION AND TRANSAXLES
HEATING AND AIR CONDITIONING

The activity which is the subject of this report was supported in whole or in part by funds from the Department of Elementary and Secondary Education, Division of Vocational and Adult Education. However, the opinions expressed herein do not necessarily reflect the position or policies of the Missouri Department of Elementary and Secondary Education or the Division of Vocational and Adult Education, and no official endorsement should be inferred.

AUTO MECHANICS CURRICULUM

MODULE 3: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

INSTRUCTOR'S GUIDE

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314/882-2884
July 1990

Catalog No. 70-183B-I

FOREWORD

Once again, we are indebted to the teachers and administrators who provide their time, efforts, and professionalism to develop curriculum for trade, technical, and industrial education programs. The Engine Performance: Section B: Fuel and Exhaust Systems module (the third of nine modules to make up the Missouri Auto Mechanics Curriculum Guide) is an outstanding example of what can be accomplished when the right people with the right attitude work together. The curriculum writers and subject matter experts who worked on this guide are to be commended for a job well done.

The module's format has been developed for competency-based teaching and testing. Job sheets within the guide evaluate specific competencies and can be managed with the Vocational Administrative Management System (VAMS). All major components of the module have been keyed to the Missouri Auto Mechanics Competency Profile, which was developed by industry and education professionals within Missouri.

Special appreciation is given to Larry Rains, the module's writer. Special appreciation is also given to Fred Smith, who served as a technical adviser during production of the module.

The format and curriculum management system found in this module may be new to many vocational educators. However, we are confident that, when used as designed, this module will allow for a more productive and rewarding educational experience for both teacher and student. Any future auto mechanics curriculum modifications will begin with the Missouri Auto Mechanics Curriculum Guide. Auto mechanics, like many technical fields, is undergoing constant and considerable change. We will annually evaluate the need to update this guide on a module-by-module basis. Your suggestions regarding areas for improvement are both encouraged and appreciated.

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Department of Elementary and Secondary Education

Charles Waibel, Director
Industrial Education
Department of Elementary and Secondary Education

ACKNOWLEDGEMENTS

Engine Performance: Section B: Fuel and Exhaust Systems is the third of nine modules that make up the Missouri Auto Mechanics Curriculum Guide. Produced by the Instructional Materials Laboratory (IML), the guide represents a continuing commitment to Missouri's Vocational Instructional Management System (VIMS). All modules in the guide are based on the Missouri Auto Mechanics Competency Profile, which in turn is based on and cross-referenced to the ASE task list. For years ASE has set the professional standards for automotive technicians. Therefore, a strong ASE orientation makes the guide an effective tool for preparing students to enter the technologically advanced field of auto mechanics.

IML extends special recognition to Larry Rains, the writer of Engine Performance: Section B: Fuel and Exhaust Systems. Mr. Rains' thorough knowledge of automotive technology and years of teaching experience are evident throughout his work. Special recognition also goes to Fred Smith, who contributed heavily to the module as a technical adviser. Mr. Smith's attention to technical detail proved invaluable throughout the module's development.

IML gratefully acknowledges the important contribution of the advisory committee, which, among other tasks, developed the competency profile for the guide. The advisory committee members are listed below:

Advisory Committee Members

Charles Waibel and Judith Moore, Division of Vocational and Adult Education, Department of Elementary and Secondary Education, Jefferson City, Mo.
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Sam Smith, Chillicothe AVTS, Chillicothe, Mo.
Wayne Sweatt, Lake AVTS, Camdenton, Mo.
Darwin Kraenow, Linn Technical College, Linn, Mo.

IML also acknowledges the fieldtesters, who worked to ensure that the Engine Performance: Section B: Fuel and Exhaust Systems module was developed into an effective and practical teaching tool. The fieldtesters are listed below:

Fieldtesters

Robert Barbarick, Four Rivers AVTS, Washington, Mo.
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Ted Scarbrough, Arcadia Valley AVTS, Ironton, Mo.
Wayne Sweatt, Lake AVTS, Camdenton, Mo.

The support and contributions of the following IML staff members were instrumental to the development of this module:

Instructional Materials Laboratory Staff

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Amon Herd, Associate Director
Phyllis Miller, Assistant Director
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Sharon Dyer, Graphic Artist II
Lori Holliday, Word Processor Operator III
Wei Li, Graduate Assistant

CONTENTS OF THE ENGINE PERFORMANCE: SECTION B: FUEL AND EXHAUST SYSTEMS MODULE

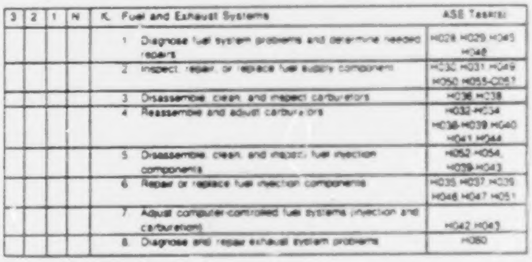
UNIT I: FUEL SUPPLY SYSTEMS .... EP/FS 1
UNIT II: CARBURETION .... EP/FS 55
UNIT III: CARBURETOR SERVICE .... EP/FS 95
UNIT IV: GASOLINE ENGINE ELECTRONIC FUEL INJECTION .... EP/FS 145
UNIT V: DIESEL FUEL INJECTION .... EP/FS 203
UNIT VI: EXHAUST SYSTEMS AND TURBOCHARGERS .... EP/FS 255

HOW TO USE THE MISSOURI AUTO MECHANICS CURRICULUM GUIDE

Every module of the Missouri Auto Mechanics Curriculum Guide contains the following seven major components: (1) a competency profile, (2) objective sheets, (3) information sheets, (4) assignment sheets, (5) job sheets, (6) tests, and (7) a cross-reference table. Below is a discussion of the design of these components.

MISSOURI COMPETENCY PROFILE

The competency profile identifies 144 basic auto mechanics competencies. The profile divides the competencies into nine general areas, each of which serves as the basis for individual modules of instruction (such as the Engine Performance: Section B: Fuel and Exhaust Systems module). The competency profile further divides these general areas into duty bands, each of which is identified by a capital letter. The Engine Performance: Section B: Fuel and Exhaust Systems module covers Duty Band K, "Fuel and Exhaust Systems." Under each duty band are listed several competencies, each of which is identified by an Arabic numeral. Note the below excerpt from the competency profile:



3	2	1	N	K. Fuel and Exhaust Systems	ASE Task(s)
				1 Diagnose fuel system problems and determine needed repairs	H028 H029 H045 H048
				2 Inspect, repair, or replace fuel supply component	H030 H031 H049 H050 H055-H057
				3 Disassemble, clean, and inspect carburetors	H036 H038
				4 Reassemble and adjust carburetors	H032-H034 H036-H039 H040 H041 H044
				5 Disassemble, clean, and inspect fuel injection components	H052 H054, H039-H043
				6 Repair or replace fuel injection components	H035 H037 H039 H046 H047 H051
				7 Adjust computer-controlled fuel systems (injection and carburetion)	H042 H043
				8 Diagnose and repair exhaust system problems	H060

In this excerpt, the duty band "Fuel and Exhaust Systems" is identified by the letter "K." The competency "Diagnose fuel systems and determine needed repairs" falls under Duty Band K and is identified by the Arabic numeral "1." Throughout the Engine Performance: Section B: Fuel and Exhaust Systems module, therefore, the competency "Diagnose fuel systems and determine needed repairs" will be referred to as Competency K1. Other competencies under Duty Band K include K2,"Inspect, repair, or replace fuel supply component," and K3 "Disassemble, clean, and inspect carburetors."

Also note that one or more ASE tasks are listed to the right side of each competency on the profile. These ASE tasks are directly related to those competencies by which the tasks appear.

(**NOTE:** The term "cross-reference table" will appear throughout the rest of this discussion. A cross-reference table is a chart that shows precisely how objectives, assignment sheets, test questions, and job sheets are related to individual competencies. The cross-reference table will be discussed later in more detail.)

INFORMATION SHEETS

The information sheets (or information outline) present the student with important facts and concepts relating to basic automotive technology and service procedures. The information sheets also explain why a procedure is necessary and why it must be performed in a certain manner. Though not intended to be as comprehensive as a textbook, the information sheets provide a good source of information to which the student can refer outside of class. Perhaps the information sheets can best be thought of as a thorough set of notes accompanying the instructor's classroom lecture.

ASSIGNMENT SHEETS

The assignment sheets serve one of two functions: they can either emphasize important cognitive information or instruct students in developing procedures specific to a particular vehicle. The "Notes to the Instructor," found on the table of contents section of each module, indicates how each assignment sheet is used.

(**NOTE:** Assignment sheets are not used to evaluate competencies directly. Only job sheets directly evaluate competencies.)

UNIT TESTS

Unit tests cover information relating to specific competencies. The student must obtain acceptable test scores (decided upon by the instructor) before receiving an evaluation for these competencies. (Since job sheets are used to evaluate competencies, the student, therefore, must receive an acceptable test score before doing certain job sheets.) The test ensures that the student has the minimum knowledge required to perform the competencies covered on the job sheets. On most tests, one group of questions covers information related exclusively to two or three competencies while another group of questions relates exclusively to several other competencies. Questions relating to a specific group of competencies are divided into parts. At the end of each part, a note like the following appears:

(NOTE: The student must obtain a minimum score of _____ on Part III of the Unit III Test in order to receive an evaluation for Competencies K4 and K7.)

All the test questions and job sheets related to each competency are listed on the module's cross-reference table. The cross-reference table allows the instructor to determine what test questions a student must successfully complete before being eligible to perform the job sheets related to a particular competency. By observing the test notes and using the cross-reference table, the instructor can easily determine what job sheets a student is eligible to do as a result of his or her score on a particular part of a test.

OBJECTIVE SHEETS

The first page of each unit in the guide is an objective sheet, which states the unit's general and specific objectives. Below is the objective sheet for Unit II of the Engine Performance: Section B: Fuel and Exhaust Systems module:

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT II: CARBURETION

UNIT OBJECTIVE

After completing this unit, the student should be able to identify and describe the functions of various carburetor components. The student will demonstrate mastery of the material by achieving a score of ______ on the unit test.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1

I. Identify the terms and definitions associated with carburetion (Competencies K1-K4, Unit II Test).

II. Identify the basic principles of carburetor operation (Competencies K1-K4, Unit II Test).

III. Identify the functions of the float circuit (Competencies K1-K4, Unit II Test).

IV. Identify the functions of the main metering circuit (Competencies K1-K4, Unit II Test).

V. Identify the functions of the idle circuit (Competencies K1-K4, Unit II Test).

VI. Identify the functions of the power enrichment circuit (Competencies K1-K4, Unit II Test).

VII. Identify the functions of the accelerator pump circuit (Competencies K1-K4, Unit II Test).

VIII. Identify the components and functions of the choke system (Competencies K1-K4, Unit II Test).

Lesson 2

I. Identify the various types of carburetors (Competencies K1-K4, Unit II Test).

II. Identify the various carburetor control devices and their functions (Competencies K1-K4, Unit II Test).

III. Identify the principles of electronic feedback carburetion (Competencies K1-K4, Unit II Test).

IV. Identify the purpose and design of intake manifolds (Competencies K1-K4, Unit II Test).

ASE TASKS COVERED IN THIS UNIT

I. Only material that is preliminary to ASE tasks appears in this unit; therefore, no ASE tasks are covered directly.

Notice that the specific objectives are designated by Roman numerals. Also notice that the competency (or competencies) to which each objective relates is listed in parentheses behind each objective. Also listed in parentheses is the method by which the student's ability to perform the objective is evaluated.

A note identifying the ASE tasks that are covered by the unit's job sheets appears at the end of every objective sheet.

JOB SHEETS

Besides giving the student practical, hands-on experience in auto mechanics, job sheets provide a means of evaluating a student's ability to perform the competencies. The job sheets are, therefore, the key component of the Missouri Auto Mechanics Curriculum Guide. Below is an excerpt from the first page of a typical job sheet in the Engine Performance: Section B: Fuel and Exhaust Systems module:

JS1-L1-UIII

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

INSPECTING AND DIAGNOSING THE FUEL SYSTEM

Equipment:

Hand tools
Hand vacuum pump
Serviceable vehicle
Safety glasses

Procedure:

		Evaluation 3 2 1 N
1.	Wear safety glasses while doing all procedures on this job sheet.	___ ___ ___ ___
	(NOTE: The test should begin with a cold engine. A cold engine is one that has not been run for 8 hours or more.)	
2.	Inspect air filter, filter housing, and ducts.	___ ___ ___ ___
	OK____ NOT OK____	

Notice that the job sheet is identified as JS1-L1-UIII, which translates into Job Sheet 1, Lesson 1, Unit III. This shorthand system of job sheet identification is used throughout the curriculum guide.

(**NOTE:** Assignment sheets are identified with the same shorthand system. Assignment Sheet 1, Lesson 1, Unit III would be AS1-L1-UIII.)

(**NOTE:** Both job sheets and assignment sheets are numbered consecutively within unit lessons.)

Also notice that, in the above job sheet excerpt, the spaces to the right of the page allow the instructor to evaluate the student on a particular job sheet activity. These spaces appear only by numbered items, which represent significant tasks; therefore, the instructor is freed from having to evaluate the minor steps of a procedure. At the beginning of each job sheet, the heading "3 2 1 N" indicates the four possible evaluations a student can receive. The meaning of the numbers and the letter N is as follows:

3 = Mastered - can work independently with no supervision
2 = Requires Supervision - can perform job completely with limited supervision
1 = Not Mastered - requires instruction and close supervision
N = No exposure - no experience or knowledge in this area

The individual evaluations made throughout a job sheet are averaged together at the end of the job sheet. A note at the end of the job sheet explains how this average relates to the final evaluation for a particular competency. Shown below is a hypothetical example of note found at the end of a job sheet. The note explains that the average of the individual evaluations made throughout the job sheet is a partial evaluation for Competency A1. (Please note that the below example is hypothetical; the Engine Performance: Section B: Fuel and Exhaust Systems Module contains no Competency A1.)

*Average of above evaluations __ __ ___

(*This average is the final evaluation for Competency A1.)

As automotive instructors know, an automobile contains many complex and interrelated components. A single general service task may involve several different procedures. In the Missouri Auto Mechanics Curriculum Guide, therefore, a competency may be evaluated over several job sheets; also one job sheet may evaluate several competencies. [illegible]gh other modules in the Missouri Auto Mechanics Curriculum Guide do evaluate competencies with [illegible]e job sheet, all job sheets in the Engine Performance: Section B: Fuel and Exhaust Systems mod[illegible]aluate competencies over several job sheets. As will be demonstrated later, each job sheet is accompanied by a thorough set of instructions, explaining how each of the final job sheet averages is to be used. The cross-reference table is also quite helpful in showing which job sheets evaluate which competencies.

CROSS-REFERENCE TABLE

The cross-reference table can quickly reveal how competencies relate to instructional objectives, job sheets, assignment sheets, and test items. Note the following excerpt from the Engine Performance: Section B: Fuel and Exhaust Systems module cross-reference table:

MODULE: ENGINE PERFORMANCE (SECTION B: FUEL AND EXHAUST SYSTEMS)
CROSS-REFERENCE TABLE OF INSTRUCTIONAL MATERIALS

Competency	Instructional Objective	Assignment Sheet	Job Sheet	Test Item	Notes
K1	UII-L1-I, UII-L1-II, UII-L1-III, UII-L1-IV, UII-L1-V, UII-L1-VI, UII-L1-VII, UII-L1-VIII, UII-L2-I, UII-L2-II, UII-L2-III, UII-L2-IV, UIII-L1-I, UIV-L1-I, UIV-L1-II, UIV-L1-III, UIV-L1-IV, UIV-L1-V, UIV-L1-VI, UIV-L1-VII, UIV-L1-VIII, UIV-L2-I, UVI-L2-I, UVI-L2-II, UVI-L2-III, UVI-L2-IV, UVI-L2-V, UVI-L3-I, UVI-L3-II	AS1-L2-UIV AS1-L3-UVI	JS1-L1-UIII JS1-L2-UIV JS1-L3-UVI JS2-L3-UVI	UII 1-45 UIII 1-8 UIV 1-25 UIV 26-32 UVI 1-20	

The above excerpt lists all the instructional objectives in the module that cover Competency K1. The cross-reference table also indicates the test questions that cover Competency K1. Just as importantly, the table reveals at a glance that the student must perform JS1-L1-UIII, JS1-L2-UIV, JS1-L3-UVI, and JS2-L3-UVI before he or she can receive an evaluation for Competency K1. By looking at the cross-reference table, the instructor can, therefore, quickly determine what test questions a student needs to answer and what job sheets a student needs to perform before receiving a final evaluation for a particular competency.

HOW AND WHY COMPETENCIES ARE EVALUATED OVER SEVERAL JOB SHEETS

According to the competency profile, Competency K1 ("Diagnose fuel system problems and determine needed repairs") covers 4 ASE tasks. A job sheet covering all of these ASE tasks would be unreasonably long and overly complicated. As was indicated above, the Missouri Auto Mechanics Curriculum Guide allows the student to perform several job sheets in order to receive an evaluation for Competency K1. These job sheets are listed below:

JS1-L1-UIII: Inspecting and Diagnosing the Fuel System
JS1-L2-UIV: Diagnosing Electronic Fuel Injection
JS1-L3-UVI: Performing a Test of Turbocharger
JS2-L3-UVI: Removing and Replacing a Turbocharger

The activities in the above job sheets satisfy Missouri Competency K1 and the ASE tasks that accompany K1. At the end of each job sheet relating to K1, a note explains that the individual evaluations made throughout the job sheet are averaged together to determine a partial evaluation for K1. The note also indicates on what job sheet the final evaluation for K1 will be determined. Below is an example of the note found at the end of JS1-L1-UIII:

*Average of above evaluations ___ ___ ___ ___

(*This average is a partial evaluation for Competency K1. Final evaluation for K1 will be made at the end of JS2-L3-UVI.)

At the end of JS2-L3-UVI, the following instructions explain how the final evaluation for K1 is to be made:

*Average of above evaluations ___ ___ ___ ___

(*This average is a partial evaluation for Competency K1. Final evaluation for K1 will be made below.)

FINAL EVALUATION INSTRUCTIONS

1. Determine the student's final evaluation for Competency K1 by averaging the evaluations of JS1-L1-UIII, JS1-L2-UIV, JS1-L3-UVI, and JS2-L3-UVI. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS1-L1-UIII	___	___	___	___
JS1-L2-UIV	___	___	___	___
JS1-L3-UVI	___	___	___	___
JS2-L3-UVI	___	___	___	___
Final evaluation for Competency K1	___	___	___	___

The content of the Engine Performance: Section B: Fuel and Exhaust Systems module is organized in the most teachable manner possible; therefore, content relating to Competency K1 is covered in Unit III, Unit IV, and Unit VI. The job sheets evaluating K1, therefore, appear in all three of these units rather than being grouped together. Again, the job sheet notes and the cross-reference table make it easy to identify and assign the job sheets that relate to a specific competency.

Some job sheets in the Engine Performance: Section B: Fuel and Exhaust Systems module cover more than one competency. For example JS3-L2-UIII, "Adjusting Propane Enrichment Idle Mixture," covers Competencies K4 and K6. Shown below is the note for JS3-L2-UIII:

(*This average is a partial evaluation for Competencies K4 and K6. Final evaluation for K4 will be made at the end of JS3-L2-UIII. Final evaluation for K6 will be made at the end of JS4-L2-UV.)

Job sheet notes sometimes vary to reflect the content of the job sheet. The information in the note, however, is always presented in a straight-forward, easy-to-understand manner.

PACKAGING OF THE AUTO MECHANICS CURRICULUM GUIDE

Each module in the Auto Mechanics Curriculum Guide is packaged in three components: an instructor's guide, a student reference, and student work sheets. The instructor's guide includes the following items, all of which are color coded:

Cross-reference table (color-coded white)
Objective sheets (color-coded white)
Table of contents, references, notes to the instructor, answer sheets for assignment sheets and tests (color-coded pink)
Information sheets (color-coded green)
Assignment sheets (color-coded tan)
Job sheets (color-coded blue)
Unit tests (color-coded yellow)

The student reference contains copies of the objective sheets and information sheets from the instructor's guide. The student work sheets include consumable items from the instructor's guide, such as job sheets, assignment sheets, and unit tests. For convenience, the page numbers of the items in the student reference and in the work sheets are the same as those in the instructor's guide; therefore, page numbers in the student reference and work sheets are not consecutive. All student reference pages and work sheet pages are white.

Competency profiles for the guide are packaged in groups of ten along with a copy of the ASE task list.

MODULE: ENGINE PERFORMANCE (SECTION B: FUEL AND EXHAUST SYSTEMS)
CROSS-REFERENCE TABLE OF INSTRUCTIONAL MATERIALS

Competency	Instructional Objective	Assignment Sheet	Job Sheet	Test Item	Notes
K1	UII-L1-I, UII-L1-II, UII-L1-III, UII-L1-IV, UII-L1-V, UII-L1-VI, UII-L1-VII, UII-L1-VIII, UII-L2-I, UII-L2-II, UII-L2-III, UII-L2-IV, UIII-L1-I, UIV-L1-I, UIV-L1-II, UIV-L1-III, UIV-L1-IV, UIV-L1-V, UIV-L1-VI, UIV-L1-VII, UIV-L1-VIII, UIV-L2-I, UVI-L2-I, UVI-L2-II, UVI-L2-III, UVI-L2-IV, UVI-L2-V, UVI-L3-I, UVI-L3-II	AS1-L2-UIV AS1-L3-UVI	JS1-L1-UIII JS1-L2-UIV JS1-L3-UVI JS2-L3-UVI	UII 1-45 UIII 1-8 UIV 1-25 UIV 26-32 UVI 1-20	
K2	UI-L1-I, UI-L1-II, UI-L1-III, UI-L1-IV, UI-L1-V, UI-L1-VI, UI-L1-VII, UI-L2-I, UI-L2-II, UI-L2-III, UI-L2-IV, UI-L2-V, UII-L1-I, UII-L1-II, UII-L1-III, UII-L1-IV, UII-L1-V, UII-L1-VI, UII-L1-VII, UII-L1-VIII, UII-L2-I, UII-L2-II, UII-L2-III, UII-L2-IV, UV-L1-I, UV-L1-II, UV-L1-III, UV-L1-IV, UV-L2-I, UV-L2-II	AS1-L2-UI AS2-L2-UI AS3-L2-UI AS4-L2-UI AS5-L2-UI AS1-L2-UV	JS1-L2-UI JS2-L2-UI JS3-L2-UI JS4-L2-UI JS5-L2-UI JS1-L2-UV	UI 1-40 UII 1-45 UV 1-15 UV 16-20	
K3	UII-L1-I, UII-L1-II, UII-L1-III, UII-L1-IV, UII-L1-V, UII-L1-VI, UII-L1-VII, UII-L1-VIII, UII-L2-I, UII-L2-II, UII-L2-III, UII-L2-IV, UIII-L1-III, UIII-L1-IV	AS1-L1-UIII AS2-L1-UIII	JS2-L1-UIII JS3-L1-UIII	UII 1-45 UIII 9-25	
K4	UII-L1-I, UII-L1-II, UII-L1-III, UII-L1-IV, UII-L1-V, UII-L1-VI, UII-L1-VII, UII-L1-VIII, UII-L2-I, UII-L2-II, UII-L2-III, UII-L2-IV, UIII-L1-II, UIII-L1-IV, UIII-L1-V, UIII-L2-I, UIII-L2-II, UIII-L2-III	AS1-L1-UIII AS2-L1-UIII AS1-L2-UIII AS2-L2-UIII AS3-L2-UIII	JS2-L1-UIII JS3-L1-UIII JS1-L2-UIII JS2-L2-UIII JS3-L2-UIII	UII 1-45 UIII 25-38	

Competency	Instructional Objective	Assignment Sheet	Job Sheet	Test Item	Notes
K5	UIV-L1-I, UIV-L1-II, UIV-L1-III, UIV-L1-IV, UIV-L1-V, UIV-L1-VI, UIV-L1-VII, UIV-L1-VIII, UIV-L2-II, UV-L1-I, UV-L1-II, UV-L1-III, UV-L1-IV, UV-L2-III, UV-L2-IV	AS5-L2-UIV AS2-L2-UV	JS5-L2-UIV JS2-L2-UV	UIV 1-25 UIV 33-36 UV 1-15 UV 21-26	
K6	UIV-L1-I, UIV-L1-II, UIV-L1-III, UIV-L1-IV, UIV-L1-V, UIV-L1-VI, UIV-L1-VII, UIV-L1-VIII, UIV-L2-II, UIV-L2-III, UIV-L2-IV, UIV-L2-V, UV-L1-I, UV-L1-II, UV-L1-III, UV-L1-IV, UV-L2-V, UV-L2-VI	AS2-L2-UIII AS3-L2-UIII AS2-L2-UIV AS3-L2-UIV AS4-L2-UIV AS3-L2-UV AS4-L2-UV	JS2-L2-UIII JS3-L2-UIII JS2-L2-UIV JS3-L2-UIV JS4-L2-UIV JS3-L2-UV JS4-L2-UV	UIV 1-25 UIV 37-45 UV 1-15 UV 27-34	
K7	UIII-L1-III, UIII-L1-IV, UIII-L2-II, UIII-L2-III, UIV-L1-I, UIV-L1-II, UIV-L1-III, UIV-L1-IV, UIV-L1-V, UIV-L1-VI, UIV-L1-VII, UIV-L1-VIII, UIV-L2-VI	AS1-L1-UIII AS2-L1-UIII AS5-L2-UIV	JS2-L1-UIII JS3-L1-UIII JS5-L2-UIV	UIII 26-38 UIV 1-25 UIV 46-50	
K8	UVI-L1-I, UVI-L1-II, UVI-L1-III	AS1-L1-UVI AS2-L1-UVI	JS1-L1-UVI JS2-L1-UVI JS3-L1-UVI	UVI 21-35	

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT I: FUEL SUPPLY SYSTEMS

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the components of various fuel supply systems and the functions of the components. The student will demonstrate mastery of the material by achieving a score of ______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the terms and definitions associated with fuel supply systems (Competency K2, Unit I Test).

II. Identify the various components of an automotive fuel supply system (Competency K2, Unit I Test).

III. Identify the construction and operation of the fuel tank (Competency K2, Unit I Test).

IV. Identify the construction and operation of fuel lines (Competency K2, Unit I Test).

V. Identify the construction and operation of fuel filters (Competency K2, Unit I Test).

VI. Identify the construction and operation of mechanical and electrical fuel pumps (Competency K2, Unit I Test).

VII. Identify the construction and operation of the fuel pressure regulator (Competency K2, Unit I Test).

Lesson 2.

I. Identify the procedures for fuel tank service (Competency K2, Unit I Test).

II. Identify the procedures for fuel line service (Competency K2, Unit I Test).

III. Identify the procedures for fuel filter service (Competency K2, Unit I Test).

IV. Identify the procedures for mechanical fuel pump service (Competency K2, Unit I Test).

V. Identify the procedures for electrical fuel pump service (Competency K2, Unit I Test).

VI. Demonstrate the ability to:

   a. Inspect and replace fuel tanks (Competency K2, JS1-L2-UI).

   b. Test mechanical fuel pump performance (Competency K2, JS2-L2-UI).

   c. Test electrical fuel pump performance (Competency K2, JS3-L2-UI).

d. Replace gasoline engine fuel filters (Competency K2, JS4-L2-UI).

e. Replace mechanical fuel pumps (Competency K2, JS5-L2-UI).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks H030, H031, H049, and H050.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT I: FUEL SUPPLY SYSTEMS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: FUEL SUPPLY SYSTEM COMPONENTS

    a. Information outline

    b. Assignment sheet

      AS1-L1-UI: Fuel Supply System Components

  2. Lesson 2: SERVICING FUEL SUPPLY SYSTEMS

    a. Information outline

    b. Assignment sheets

      AS1-L2-UI: Procedure for Removing and Replacing a Fuel Tank
      AS2-L2-UI: Procedure for Testing Mechanical Fuel Pump Condition
      AS3-L2-UI: Procedure For Electrical Fuel Pump Testing
      AS4-L2-UI: Procedure for Gasoline Engine Fuel Filter Replacement
      AS5-L2-UI: Procedure for Mechanical Fuel Pump Removal and Replacement

    c. Job sheets

      JS1-L2-UI: Fuel Tank Service
      JS2-L2-UI: Testing Mechanical Fuel Pumps
      JS3-L2-UI: Electrical Fuel Pump Performance Testing
      JS4-L2-UI: Fuel Filter Replacement
      JS5-L2-UI: Mechanical Fuel Pump Removal and Installation

E. Unit test

F. Answers to unit test

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General Motors Corporation. Engine Performance Testing. 1987.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L2-UI in conjunction with JS1-L2-UI; AS2-L2-UI in conjunction with JS2-L2-UI; AS3-L2-UI in conjunction with JS3-L2-UI; AS4-L2-UI in conjunction JS4-L2-UI; and AS5-L2-UI in conjunction with JS5-L2-UI.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT I: FUEL SUPPLY SYSTEMS

LESSON 1: FUEL SUPPLY SYSTEM COMPONENTS

I. Terms and definitions

Vapor lock--A condition in which the fuel pump or fuel line from the tank to the carburetor becomes partly full with fuel vapor bubbles.

Vacuum--The absence of pressure.

II. Introduction

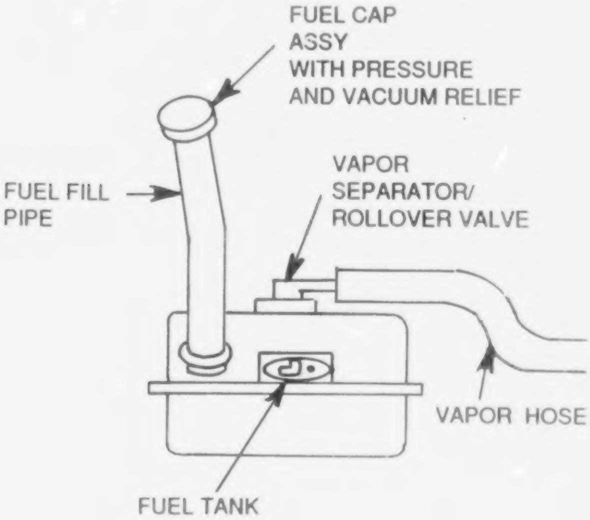
A. The duties of the automotive fuel supply system include storing, filtering, and delivering the fuel to the engine as required. The supply system must deliver a clean and constant supply of liquid fuel. Air, fuel vapors, or fuel line restrictions can cause insufficient fuel delivery.

B. There are four and sometimes five main components of the fuel supply system.

1. Fuel tank
2. Fuel lines
3. Fuel filter(s)
4. Fuel pump(s)
5. Fuel pressure regulator (not used in all systems)

III. Fuel tank

A. The fuel tank is commonly constructed of corrosion resistant steel. The steel tank is manufactured of two halves, which are welded together.


FUEL CAP
ASSY
WITH PRESSURE
AND VACUUM RELIEF
FUEL FILL PIPE
VAPOR SEPARATOR/ ROLLOVER VALVE
VAPOR HOSE
FUEL TANK

1. Fuel is added to the tank through a steel fuel filler tube that may be welded to the tank or attached through a rubber hose or grommet.

2. A restriction is installed in the fuel filler tube of modern passenger cars to prevent the filling of the tank with leaded fuel. A larger fuel nozzle is used for leaded gasoline and will not fit through the restriction. Leaded fuel will damage oxygen sensors and catalytic converters.

3. A pressure-vacuum filler cap is used on the filler tube.

    a. Older vehicles commonly used a gas tank cap with a hole in it to allow venting of fuel vapors and to allow atmospheric pressure into the tank, which is necessary during fuel pump operation.

    b. Modern vehicles use a pressure-vacuum filler cap. This cap holds a slight pressure on the fuel which occurs from normal heat expansion.

    c. When pressure or vacuum exceeds the preset cap calibration, a valve opens, relieving pressure or vacuum.

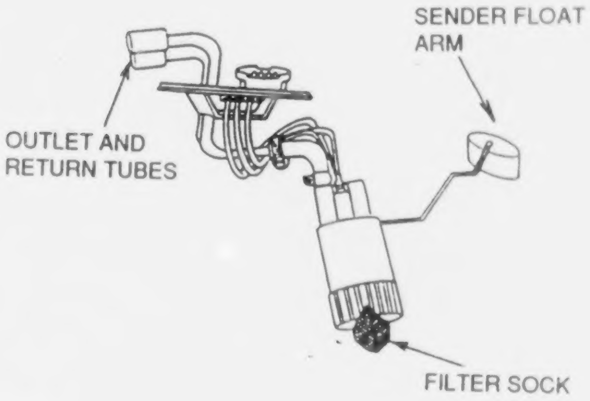
4. Steel baffle plates are installed inside the tank before assembly. These plates prevent the liquid fuel from sloshing inside the tank and also help keep the fuel pickup tube immersed in gas during hard cornering.

5. An opening is provided in the tank for installation of the fuel sending unit and pickup gauge.

    a. The fuel gauge sending unit is commonly attached to the fuel pickup tube.

    b. The fuel pickup tube extends near but not completely to the bottom of the fuel tank. This prevents water, rust, and other contaminants from being drawn into the fuel tank filter.

    c. The fuel tank filter is commonly called a sock and is attached to the end of the tube. It is always immersed in fuel.



    d. An in-tank electrical fuel pump is also installed in some vehicles. The fuel pump may be separate from or integral with the sending unit assembly.

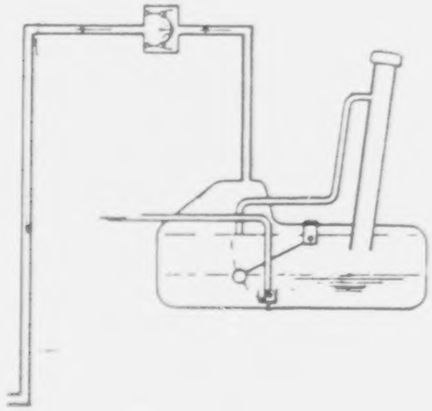
B. Some vehicles are using fuel tanks made of aluminum or molded polyethylene for weight savings.

C. A fuel expansion area is normally provided to contain vapors and allow for expansion and contraction and to prevent overflow that results from changes in temperature of the fuel.

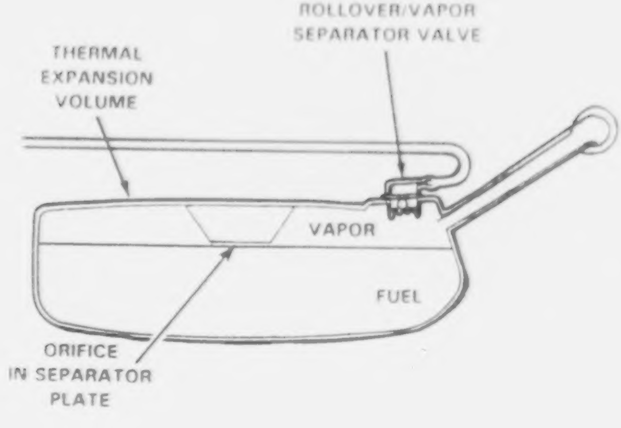
1. During fueling, the cold fuel pumped out of underground tanks enters the vehicle fuel tank. The warmer outside temperature causes the fuel to expand and evaporate. Hot vehicle exhaust may also cause expansion and evaporation of the fuel.

   (NOTE: Older vehicles vented this evaporated fuel to the atmosphere. Venting the fuel in this manner polluted the air and caused a fire hazard. Today's vehicles provide an expansion area in the fuel tank that eliminates the need for this type of external venting.)

2. The fuel tank top may have a domed or bubble shape. An overfill limiter tube prevents fuel from filling this space.



3. In another design, the fuel tank contains an inner ceiling or separator inside the tank.



    a. The separator contains an orifice which allows fuel vapor to enter the expansion volume. The orifice allows expanding fuel vapor to flow into the expansion volume until the fuel level reaches the orifice. Then the restriction causes a back pressure in the fuel filler tube, which cuts off the fuel fill nozzle flow.

    b. The volume of air above the separator prevents against overfilling.

  4. Excessive fuel vapors leave the fuel tank and travel through a line to a charcoal canister, which is normally located at the front of the vehicle.

    a. When the engine is started, the fuel vapors are mixed with fresh air and drawn into the intake manifold of the engine and into the cylinders where the vapors are burned along with the normal fuel mixture.

    b. This system will be discussed further in the emissions section of this module.

    (NOTE: Diesel engine equipped vehicles do not require a vapor recovery system such as the one just described.)

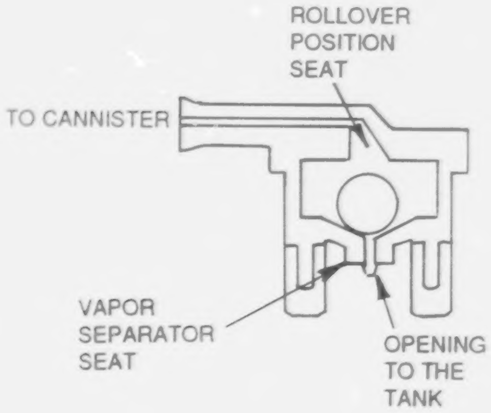
D. Rollover protection

  1. Since the mid 1970's, federal regulations have required that automotive fuel systems be protected against leakage when a vehicle rollover occurs.

  2. Pressure-vent fuel caps normally have settings that are high enough to prevent fuel pressure from opening the pressure release in the cap and allowing fuel leakage in the event of a rollover.

  3. Rollover/vapor separator valve

    a. This part contains a single check ball, which uses gravity for two functions.



    b. As long as the vehicle is upright, the weight of the ball seals a lower passage. This seals tank pressure until vapor pressure can raise the ball for venting to the charcoal canister. The design prevents liquid from passing; therefore, liquid is separated from vapor.

    c. In the case of vehicle rollover, the ball will block the upper outlet. Gravity will hold the ball in position and stop fuel leakage from the tank.

IV. Fuel lines

A. Fuel lines may be made of steel, reinforced fuel resistant rubber, or nylon tubing.

1. Steel or nylon fuel lines are generally used between the fuel tank and engine compartment. The fuel lines generally follow along the inside of a frame rail.

2. Rubber hose is normally used to connect the steel line to the fuel tank and to the engine. The rubber hose gives the required flexibility to the connections. The rubber hose must be fuel resistant and be made of reinforced material which can withstand the vacuum and pressure that occur in a fuel system.

(NOTE: Fuel injection systems require hoses capable of withstanding pressure of 50 psi or greater.)

(**CAUTION:** Rubber hose and other synthetic lines should never be used within 4 inches of any part of an exhaust system.)

V. Fuel filters

A. Gasoline engine fuel filters

1. Automotive gasoline engines normally have two fuel filters. One is an in-tank filter which, as mentioned above, is referred to as a sock. The second is a serviceable filter, which is generally mounted in line or at the carburetor inlet.

2. As mentioned earlier, the in-tank filter fits over the end of the pickup tube. The sock is constructed of a very finely woven synthetic fabric. This filter strains out dirt particles and tends to separate water from the fuel.

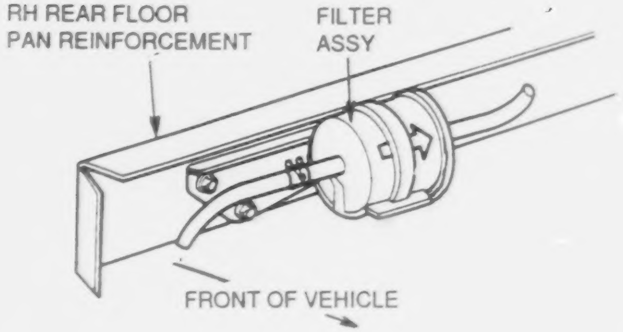
a. The sock is not serviced on a regular basis. Replacing it often requires draining and removal of the fuel tank.

b. In the case of a vehicle equipped with an in-tank electrical fuel pump, the sock is attached to the pump inlet.

3. The in-line fuel filter is one of three basic types of serviceable fuel filters.

a. The in-line fuel filter is generally constructed of a pleated paper filtering element enclosed in a plastic or metal shell.

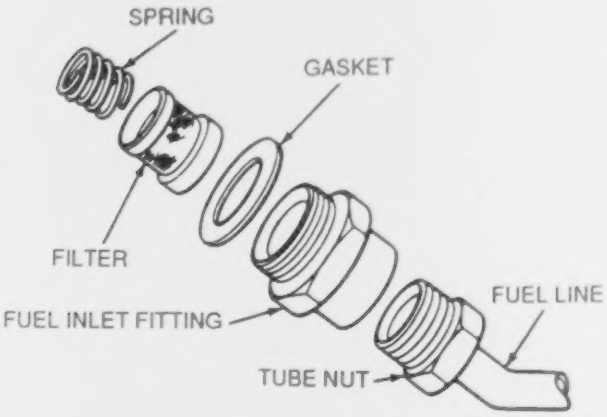
b. On carbureted engines, the in-line fuel filter is usually located in the engine compartment between the fuel pump and carburetor. However, many fuel-injected and imported vehicles place this filter between the tank and the engine compartment.



4. In-carburetor filter

   a. There are two common types of in-carburetor filters: the pleated paper or sintered bronze types. In-carburetor filters are generally found on General Motors vehicles.

   b. Both the pleated paper and the sintered bronze in-carburetor filters are installed in the carburetor inlet behind the inlet fitting.



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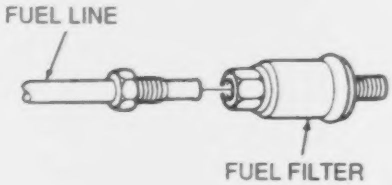
   c. Newer vehicles with the pleated paper filter contain a check valve, which is pressed into the filter's neck. This check valve consists of a plastic in a plastic retainer which is held in the normally closed position by a small spring which exerts pressure on the check valve.

   d. When the engine starts and fuel flow pressure from the pump enters the inlet nut, the small check valve is pushed off its seat.

   e. Fuel flow passes the valve and moves to the inside of the filter. Fuel flow continues on through the filter to the float needle valve and seat.

   f. If the vehicle should roll over, the check valve closes (when the engine is off) and shuts off fuel flow to the carburetor to prevent leaks.

5. The screw-in type filter threads into the carburetor inlet. The fuel inlet line then attaches to the filter. This type of filter is commonly found in Ford vehicles.



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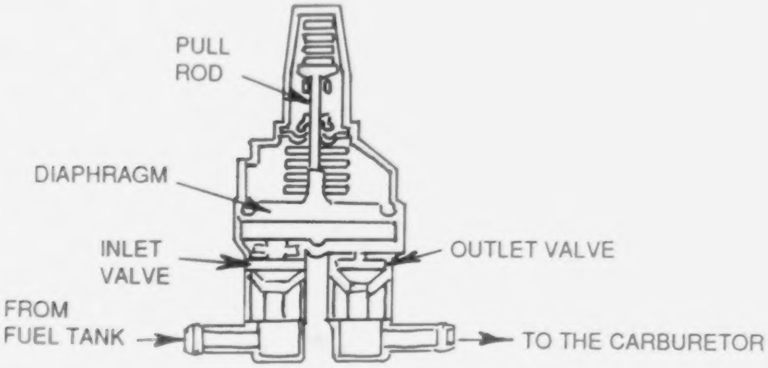
6. The fuel pump outlet design is generally a pleated paper element which is housed in a metal can attached to the fuel pump or inside the fuel pump outlet fitting.

VI. The purpose of the fuel pump is to move the fuel from the tank through the fuel lines to the carburetor or injectors. There are two basic types of fuel pumps: mechanical and electrical.

(NOTE: In the case of a diesel engine, the fuel delivery pump delivers the fuel from the tank to the high-pressure injection pump.)

A. The mechanical fuel pump is mounted to the engine and is operated by an eccentric cam that is either an integral part of or bolted to the engine camshaft. Motion is transmitted through direct between the pump lever and the cam or through a push rod between the cam and pump lever. The pump's operation is described below.

1. As the camshaft rotates, the eccentric operates a pump lever.
2. This action moves a pull rod and diaphragm against the pump main spring, creating a vacuum in the valve housing.



3. The inlet valve then opens and fuel enters the valve housing chamber.
4. On the return stroke the main spring forces the diaphragm down. The inlet valve closes and expels the fuel through the outlet valve to the fuel filter and the carburetor.
5. A third port is sometimes used, which allows excessive fuel to return to the fuel tank.

B. Electrical fuel pumps are the type of pump most often found on the vehicles manufactured today.

1. There are several benefits in using an electrical pump.
   - a. An electrical fuel pump has the capability of maintaining a constant fuel pressure.
   - b. An electrical fuel pump can be mounted at remote locations since it is not attached to the engine.
   - c. Vapor lock problems are less likely with an electrical fuel pump.
   - d. Electrical fuel pumps create no mechanical load on the engine.
2. The electrical fuel pump may be mounted on the frame rail in line between the fuel tank and engine. However, most pumps used today are submerged in-tank type pumps.

3. Bellows, impeller, and plunger as well as other types of electrical fuel pumps are used.

4. As a rule, electrical fuel pumps are not serviceable and must be replaced as a complete unit when found to be defective.

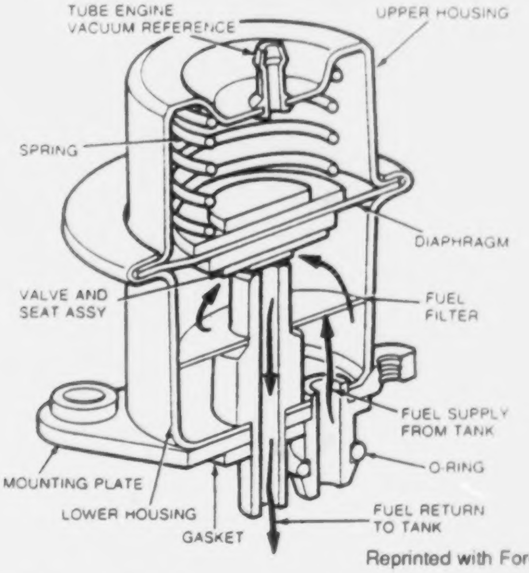
5. Depending on the type of fuel pump and its application, the pressure produced by an electrical fuel pump may range from 6 to over 50 psi.

VII. Fuel-injected gasoline engines commonly use a pressure regulator to maintain a constant fuel pressure at the injectors. Below is a description of the operation of a typical fuel pressure regulator.

A. The fuel pressure regulator contains a pressure chamber separated by a diaphragm relief valve assembly.

1. On one side of the diaphragm is fuel inlet pressure, while on the other side is a calibrated spring and engine vacuum.

2. Fuel pressure is regulated when pump pressure, acting on the bottom side of the diaphragm, overcomes the force of the spring action on the top side.



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B. A relief valve opens or closes in response to movement of the diaphragm. The valve opens or closes an orifice to control the amount of fuel returned to the tank.

C. Vacuum acting on the top side of the diaphragm, along with spring pressure, controls fuel pressure.

1. A decrease in vacuum creates an increase in fuel pressure.

2. An increase in vacuum creates a decrease in fuel pressure.

3. For example, under heavy load conditions, the engine requires more fuel flow. Vacuum decreases under heavy load conditions because of throttle opening. A decrease in vacuum allows more pressure to the top side of the pressure relief valve, thus increasing fuel pressure.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

FUEL SUPPLY SYSTEM COMPONENTS

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. List the five main fuel supply system components.

2. What term is used to refer to the in-tank fuel filter?

3. What component operates the mechanical fuel pump? (This component is either an integral part of or bolted to the engine camshaft.)

4. What component maintains a constant fuel pressure at the fuel injectors?

5. What devices placed in the fuel tank prevent the fuel from sloshing?

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

FUEL SUPPLY SYSTEM COMPONENTS

(ANSWER SHEET)

1. Fuel tank, fuel lines, fuel filter, fuel pump, fuel pressure, regulator
2. Sock
3. Eccentric cam
4. Pressure regulator
5. Baffles

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT I: FUEL SUPPLY SYSTEMS

LESSON 2: SERVICING FUEL SUPPLY SYSTEMS

I. Fuel tank service

(**CAUTION:** When working with automotive fuel systems, work in a well-ventilated area. Do not work in the presence of an open flame. Be cautious of gas-fired furnaces and hot water heaters.)

A. Procedure for inspecting the fuel tank

1. Inspect the fuel tank for any signs of physical damage.

   (**CAUTION**: To prevent sparking, which could ignite fuel vapors, use a battery-powered, low-voltage flashlight when working with fuel systems.)

   (NOTE: The location of the fuel tank is such that the tank sometimes comes in contact with objects in the road. Dents or punctures resulting from such contact are not uncommon.)

   (NOTE: If a fuel tank is leaking, place a drain pan under it immediately to catch any spillage.)

2. Inspect steel tanks for excessive rusting. A common rust point is under the metal straps that retain the tank to the vehicle.

   (NOTE: Some external surface rust is normal; however, a badly rusted tank is unsafe and should be replaced.)

3. Inspect the condition of mounting straps and inspect all mounting bolts for tightness.

   (**CAUTION**: Makeshift mounting techniques, such as using wire to support the tank, are totally unacceptable.)

4. Check fuel hoses and lines at the tank. Replace any deteriorated rubber hoses. Also replace any kinked, pinched, or improperly routed lines or hoses.

5. On cars that should use only unleaded fuel, make sure the restrictor in the filler pipe is present.

   (NOTE: These cars usually have a label at the fuel filler and on the fuel gauge indicating the use of only unleaded fuel. In some states, the laws require the restrictor to be in place before the vehicle can pass the state safety inspection.)

6. Make sure the vehicle has the proper type of gas cap and that the cap is in good condition. The gasket sealing the cap to the filler pipe should be intact and in good condition. Replace any cap found to be incorrect or defective.

   (NOTE: The cap is normally a pressure-vent type cap.)

B. Procedure for removing and replacing the fuel tank

(NOTE: Tank removal procedures vary depending on type and location of the fuel tank. Consult appropriate service manual when working with a specific vehicle.)

1. Disconnect negative battery cable.

2. Remove the fuel from the tank.

    a. Automotive fuel tanks do not normally have a drain and therefore the fuel must be siphoned or pumped out of the vehicle.

        (**CAUTION:** Never siphon fuel from a vehicle by sucking on a hose to start the flow of fuel. Automotive fuels are highly poisonous.)

    b. Special equipment can pump the fuel from the tank, filter it, and then hold it in storage until it can be returned to the tank.

    c. Another method of removing fuel from the tank involves removing the fuel outlet hose at the tank and connecting a siphon device to the tank. Fuel may then be drained into clean safety cans for storage until the tank can be refilled.

        (NOTE: If the fuel is contaminated and not to be re-used, dispose of it properly.)

        (**CAUTION**: Never drain a fuel tank in an open pan; doing so presents a fire hazard. Place fuel in sealed containers.)

3. Disconnect fuel hoses from the fuel tank. If necessary, use masking tape to mark the correct position of each hose.

    (**CAUTION**: Fuel injected vehicles with electrical fuel pumps retain high pressure in the fuel system for long periods of time after the engine is shut off. This pressure must be relieved before any fuel hoses are removed. Consult the appropriate service manual for proper procedure before removing fuel lines.)

4. Disconnect fuel gauge sending unit wiring at the tank. Disconnect in-tank electrical fuel pump wiring at the tank, if so equipped.

5. Disconnect the filler pipe from the tank.

    (NOTE: Some vehicles use a rigid filler neck--one that is permanently attached to the tank. The rigid filler neck is still generally fastened to the vehicle body near the filler cap.)

6. Loosen tank strap bolts all but about two turns.

7. While holding the tank in position with one hand, completely remove tank straps. Slowly lower the tank from under vehicle while watching for any hoses or wires that may yet be attached.

    (NOTE: A transmission jack can sometimes be used to aid in the lowering of the tank. In the case of extra large or heavy tanks, it may be necessary to have an assistant help lower the tank.)

C. Procedure for removing the fuel gauge sending unit

1. The fuel gauge sending unit may be held in place with screws or with a special retaining ring. The latter is more common on today's cars.

2. Clean the tank in the area of the sending unit to prevent any debris from falling into the tank when the sending unit is removed.

3. A special wrench is used to remove the retaining ring. If the special tool is not available, the ring can be removed by using a hammer and drift punch.

4. Turn the ring about a quarter turn with the special wrench or tap the ring by using the hammer and punch to free the sending unit.

5. After the ring is free, carefully lift the sending unit from the fuel tank. Be careful not to damage the float, float arm or sending unit.

6. In the case of an in-tank fuel pump, it is usually an integral apart of this assembly. However, some applications have the fuel gauge sender separate from the fuel pump. In such applications, the pump removal procedure is generally similar to the sending unit removal procedure.

D. Procedure for inspecting fuel gauge sending unit

1. Visually inspect unit for any damaged components.

2. Shake float unit and listen for any sloshing sounds. If fuel can be heard inside, replace the float. Some floats are made of a solid plastic and cannot be checked in this manner.

3. Inspect the condition of the filter (sock). It is a good practice always to replace the sock when the sending unit is removed.

4. Inspect the condition of the o-ring or gasket sealing the sending unit to the tank. It is a good practice always to replace the o-ring.

E. As a part of fuel tank inspection, inspect the interior of the tank with a battery-powered flashlight. If rust is found on the interior of a metal gas tank, the tank should be replaced. A dirty metal tank may be cleaned by using a steam cleaner.

(NOTE: Plastic tanks should not be steam cleaned.)

F. Procedure for repairing the fuel tank

1. Small punctures in steel tanks can sometimes be repaired by installing a sheet metal screw with a neoprene rubber washer to seal the leak.

2. Special chemical sealing compounds are available for repairing small leaks in both steel and plastic tanks.

3. Major repairs involving soldering or welding of fuel tanks should only be attempted after thorough cleaning of the tank. Because of the danger involved in this type of repair, it is best to leave gas tank repair to experts that specialize in this type of work.

G. Procedure for fuel tank installation

1. Install sending unit/fuel pump in reverse order of removal.

2. Reinstall fuel tank in vehicle in reverse order of removal.

3. Replace any defective fuel line hoses.

4. Tighten tank strap bolts/nuts to torque specified in service manual.

5. Refill fuel tank and check for leaks.

II. Fuel line service

A. Procedure for inspecting fuel lines

1. Inspect all lines for proper routing.

   (NOTE: No rubber or nylon lines should be within four inches of the exhaust system.)

2. Inspect for lines that are rubbing against moving components of the engine or suspension.

3. Inspect rubber hoses for deterioration, cracking, etc.

4. Inspect metal lines for dents, holes, and excessive rusting.

   (NOTE: A small hole in a fuel line may not cause a fuel leak but will admit air, which causes the fuel pump to draw in air instead of fuel from the tank.)

B. Repair and replacement of fuel lines

(**CAUTION:** Fuel-injected vehicles with electrical fuel pumps retain high pressure in the fuel system for long periods of time after the engine is shut off. This pressure must be relieved before any fuel hoses are removed. Consult the appropriate service manual for proper procedures before removing fuel lines.)

1. Steel line repair

   a. Sections of damaged or rusted line may be replaced by cutting out the bad portion of line and installing a section of similar tubing.

      (NOTE: Never substitute aluminum or copper for steel tubing.)

   b. Compression fittings or, more commonly, double-flare fittings are used to join the new line with the existing line.

   c. When using double-flared connections, it will be necessary to flare the tubing by using a "double flare" flaring tool.

2. Rubber hose

   a. A rubber hose may be replaced by removing and discarding the entire old hose and replacing it with a similar hose.

   b. Do not substitute with a lesser quality hose. If the hose is to be used in a high-pressure fuel injection system, replace it with a high-pressure hose.

   c. The hose is held in place with hose clamps.

3. Nylon tubing

   a. Damaged nylon tubing can be repaired by using special splice connectors.

   b. The damaged portion of the nylon tubing is cut out.

   c. A barbed splice connector is inserted into each end of the existing tubing and onto each end of a new section of tubing.

   d. The ends of the tubing are placed in boiling water for one minute prior to insertion of the barbed couplings to ease installation.

e. Special clamps are installed over the nylon line at each connection to insure a tight connection.

C. Another type of fuel line connector is the push connector. There are three different types of push connect fittings: hairpin clip fittings and duckbill clip fittings, and spring lock coupling fittings. Push connect fittings are more complex than the normal hose clamps and require special techniques and tools for service.

1. Procedure for removing a hairpin clip fitting

a. Clean dirt and foreign material from connector.

(**CAUTION:** Fuel-injected vehicles with electrical fuel pumps retain high pressure in the fuel system for long periods of time after the engine is shut off. This pressure must be relieved before any fuel hoses are removed. Consult the appropriate service manual for proper procedure before removing fuel lines.)

b. Over a period of time, the seals and tubing tend to stick to each other. To separate them, twist and then push and pull the fitting until it moves freely on the tube.

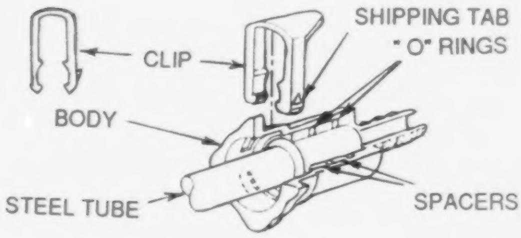
c. To remove a "hairpin" type clip from a fitting, first bend the shipping tab downward so that it will clear the body.

d. Next, spread the two clip legs about 1/8 inch to disengage the body and push the legs into the fitting.

e. Complete removal is accomplished by lightly pulling from the triangular end of the clip and working it clear of the tube and fitting.

f. Grasp the fitting and hose assembly and pull it in an axial direction to remove the fitting from the steel tube.

g. When the fitting is removed from the tube end, inspect the fitting and tube for any internal parts that may have been dislodged from the fitting. Any loose internal parts should be immediately installed, using the mating tube to insert the parts.



2. Procedure for installing the hairpin clip

a. It is recommended that the original clip not be re-used in the fitting. To install the new clip, insert the clip into the two adjacent openings with the triangular portion pointing away from the fitting opening.

b. Install clip to engage the body fully. It may be necessary to pilot the clip with the index finger.

c. Before installing the fitting on the tube, wipe tube end with a clean cloth. Inspect the inside of the fitting to ensure it is free of dirt and/or obstructions.

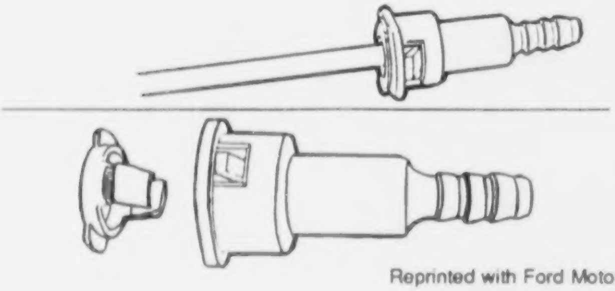
d. To install the fitting onto the tube, align the fitting and tube axially and push the fitting onto the tube end. When the fitting is engaged, a definite click will be heard. Pull on the fitting to ensure its engagement.

3. Procedure for removing the duckbill clip

a. Clean fitting before disassembly.

b. The seals and tubing tend to stick to each other over a period of time. To separate them, twist the fitting on the tube, then push and pull the fitting until it moves freely on the tube.

c. Using a special tool, disconnect the duckbill clip.



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d. To disengage the tube, align the slot on the push disconnect disassembly tool with either tab on the clip (90 degrees from the slots on side of fitting) and insert the tool. This engages the "duckbill" from the tube.

e. Holding the tool and the tube with one hand, pull the fitting away from the tube.

(NOTE: If the tube has been properly disengaged, only moderate force is required to remove the fittings. Use hands only.)

f. After disassembly, inspect and clean the tube sealing surfaces. Also inspect the inside of the fitting and the tube for any internal parts that may have been dislodged from the fitting. Any loose internal parts should be immediately installed, using the mating tube to insert the parts.

4. Procedure for installing the duckbill connector

a. The old retaining clip should not be re-used. Install the replacement clip into the body by inserting one of the retaining clip's serrated edges on the duckbill portion into one of the window openings. Push on the other side of the clip until it snaps into place.

b. Before installing the fitting on the tube, wipe the tube end with a clean cloth. Inspect the inside of the fitting to ensure it is free of dirt and/or obstructions.

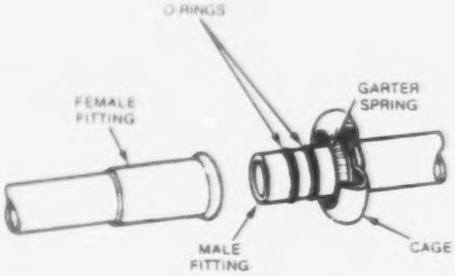
c. To install the fitting onto the tube, align the fitting and tube axially and push the fitting onto the tube end. When the fitting is engaged, a definite click will be heard. Pull on fitting to ensure it is fully engaged.

5. Spring lock couplings are yet another type of connector that is different from the common hose/line connector. The spring lock coupling is held together by a garter spring inside a circular cage.

    a. When the coupling is connected together, the flared end of the female fitting slips behind the garter spring inside the cage of the male fitting.

    b. The garter spring and cage then prevent the flared end of the female fitting from pulling out of the cage.

    c. Two o-rings seal between the two halves of the coupling. The following illustrations show how to connect and disconnect the coupling.



SPRING LOCK COUPLING DISCONNECTED

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III. Fuel filter service (gasoline engine)

A. Procedure for inspecting a fuel filter

1. Inspect fuel filters and connecting lines for leakage. Replace leaking filters.

2. Other than inspecting connecting lines, the technician can do very little to determine if a fuel filter is in good condition. The vehicle manufacturer, therefore, recommends replacement of the filter at regular intervals.

B. Replacing fuel filters (gasoline)

(**CAUTION**: Fuel injected vehicles with electrical fuel pumps retain high pressure in the fuel system for long periods of time after the engine is shut off. This pressure must be relieved before any fuel hoses are removed. Consult the appropriate service manual for proper procedure before removing fuel lines.)

1. Procedure for replacing an in-carburetor filter

    a. Clean dirt form around the fuel inlet to prevent contaminants from entering the fuel system.

    b. Place towels under the filter to absorb any fuel spilled during removal.

    c. Remove fuel inlet line. Use a backup wrench to hold the inlet fitting while loosening the fuel line.

    d. Remove the inlet fitting and remove the old fuel filter and spring.

    e. Inspect the condition of the gasket located on inlet fitting. Replace the gasket if necessary.

f. Install a new filter in reverse order of disassembly.

g. Start engine and check for fuel leakage.

2. Procedure for replacing an in-line fuel filter

a. Remove filter from mounting bracket.

b. Place towels under filter to absorb leakage.

c. Remove hose clamps or loosen and remove lines from both ends of the filter.

(**CAUTION**: On fuel injected engines, pressure will remain in the lines long after the engine is turned off. It will be necessary to bleed pressure from lines before removing filter to avoid spraying fuel. Consult applicable service manual for instructions on this procedure.)

d. Remove filter by pulling and twisting it free of hoses.

e. Install new hoses as required.

f. Replace filter in reverse order of removal.

g. Start engine and check for fuel leakage.

3. Procedure for replacing a screw-in type filter

a. Place a towel under fuel line to absorb fuel leakage; then remove fuel line from filter.

b. Unscrew filter from carburetor and discard old filter.

c. Thread new filter into carburetor and tighten.

d. Reinstall the fuel line.

e. Start engine and check for fuel leakage.

IV. Mechanical fuel pump service

(NOTE: The following tests and specifications are general. Procedures and specifications will vary, depending on the vehicle model. Consult the appropriate service manual when working with a specific vehicle.)

A. Procedure for visually inspecting a mechanical fuel pump

1. Inspect for fuel leakage at lines and at pump.

2. Inspect pump mounting bolts for tightness.

3. While the engine is running, listen for unusual or excessive noise from the fuel pump. A noisy pump is an indication of a broken pump lever or return spring.

B. Procedure for pressure testing a mechanical fuel pump

1. Disconnect fuel line at carburetor and connect a suitable pressure gauge.

(NOTE: On diesel engines, disconnect the fuel line between the fuel pump and the fuel filter on the engine.

2. Start the engine and run it at slow idle (using the fuel in the carburetor or injection pump).

3. Observe pressure gauge. Pressure should be a constant 37.9 to 44.8 kPa (5 1/2 to 6 1/2 psi). Momentarily speed engine up while continuing to observe the gauge. If pressure is too high or too low, or if pressure varies greatly when tested at different engine speeds, the pump should be replaced.

C. Procedure for vacuum testing a mechanical fuel pump

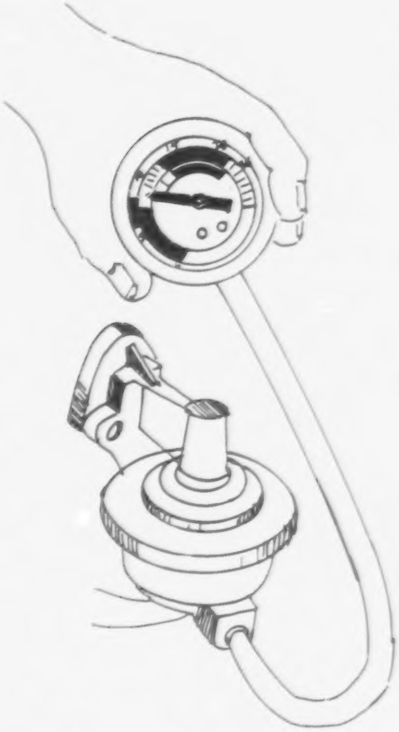
1. Disconnect the fuel line at the carburetor.

   (NOTE: Disconnecting the fuel line allows the pump to operate at full capacity; the pump must operate at full capacity to prime a dry carburetor.)

2. Disconnect line from tank at pump inlet fitting.

3. Connect a vacuum gauge to the pump inlet fitting. Start the engine and run it at idle speed.

4. Observe the vacuum gauge. Minimum reading should be at least 10 in" vacuum. If vacuum is not at least 10 in", replace the pump.

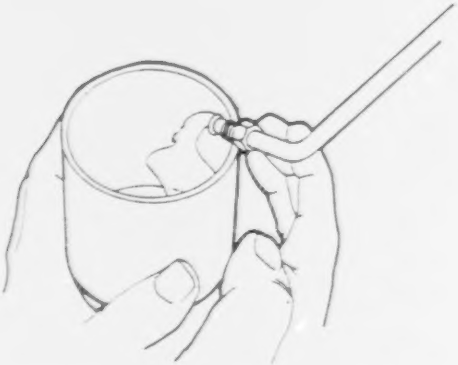


D. Procedure for conducting a mechanical fuel pump volume test

1. Disconnect the fuel line from the carburetor. On diesel engines, disconnect the fuel line between the fuel pump and the fuel filter. The fuel filter is usually located near the injection pump. Run fuel line into a suitable measuring container.

2. While observing the second hand of a clock or watch, run the engine at idle until there is one pint of fuel in the container.

3. If flow is below minimum, check for a restriction in the line. Check any filters, including the sock in the tank. If everything else appears to be in good condition, replace the fuel pump.



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E. Procedure for removing a mechanical fuel pump

1. Disconnect the fuel inlet hose form the pump. Disconnect the vapor return hose, if so equipped.

   (NOTE: Place a drain pan under the pump to catch any fuel leakage. Immediately wipe up any fuel spilled.)

2. Disconnect the fuel outlet fitting at the pump.

3. Remove the two bolts attaching the pump to the engine.

4. Remove the fuel pump.

F. Procedure for installing a mechanical fuel pump

1. Inspect the condition of all hoses and lines.

2. Replace any deteriorated hoses.

3. Repair or replace any damaged lines or fittings.

4. Thoroughly clean the pump mounting surface.

5. Install fuel pump and new gasket. Tighten mounting bolts to specified torque.

   (NOTE: Be certain that pump lever is installed correctly. An incorrectly installed pump lever can result in pump and/or engine damage.)

6. Install lines and hoses.

7. Start engine and check for leaks.

V. Electrical fuel pump service

(NOTE: Service procedures for electrical fuel pumps vary due to the differences in pump design and location within the fuel system. Consult an appropriate service manual when working with a specific system.)

A. Testing an electrical fuel pump

1. Procedures for visually inspecting an electrical fuel pump

a. When the fuel pump is isolated outside of the fuel tank, inspect for leakage. A leaking pump must be replaced.

b. Inspect the condition of lines or hoses attached to the pump. Deteriorated or damaged lines and hoses should be replaced.

2. Procedures for pressure testing an electrical fuel pump

(NOTE: The procedures for pressure testing an electrical fuel pump vary greatly, depending on the vehicle model and manufacturer. The below procedure is for a General Motors vehicle with throttle body fuel injection. The technician must consult the appropriate service manual for the specifications and procedures that apply to the particular vehicle to be serviced.)

a. Remove fuel pump fuse.

b. Crank engine. Engine will start and run until all fuel remaining in the fuel lines is consumed. Engage starter again to ensure the relief of any remaining pressure.

c. With the ignition off, replace fuel pump fuse.

d. Install an appropriate fuel pressure gauge in the pressure line between the fuel filter and the fuel inlet to the throttle body assembly.

e. Start the car and observe the fuel pressure reading. It should be 62-90 kpa (9 -13 psi). If proper reading is not obtained, refer to service manual for detailed testing procedures.

f. Relieve fuel pressure by repeating steps a, b, and c above.

g. Remove the fuel pressure gauge.

h. Reinstall the fuel line.

i. Start the car and check for fuel leakage.

3. Procedures for pressure testing an electrical fuel pump on vehicles other than those produced by General Motors are described below.

a. On most Chrysler vehicles, the technician should remove the fuel tank cap and then disconnect the electrical connector from an injector. Next, using two jumper wires, the technician should ground one injector terminal and apply battery voltage to the other. Damage may result if the injector is energized for more than ten seconds.

b. On most Ford vehicles, the technician should connect a fuel pressure gauge to the Schraeder connector on the throttle body or fuel rail. Next, the technician should open the valve leading to the drain hose on the gauge assembly and relieve system pressure into a suitable container.

(NOTE: System pressure on fuel injected engines should always be relieved before opening any part of the system. Refer to the appropriate service manual for detailed instructions.)

4. Electrical fuel pump replacement

(NOTE: The following procedure is for a pump mounted inside the fuel tank. This type of pump is serviced in much the same manner as a fuel gauge sending unit; in fact, this type of pump is sometimes integral with the sending unit. Refer to manufacturer's service manual when working with a specific vehicle.)

a. Relieve fuel system pressure (see service manual for this procedure).

b. Raise and secure the vehicle.

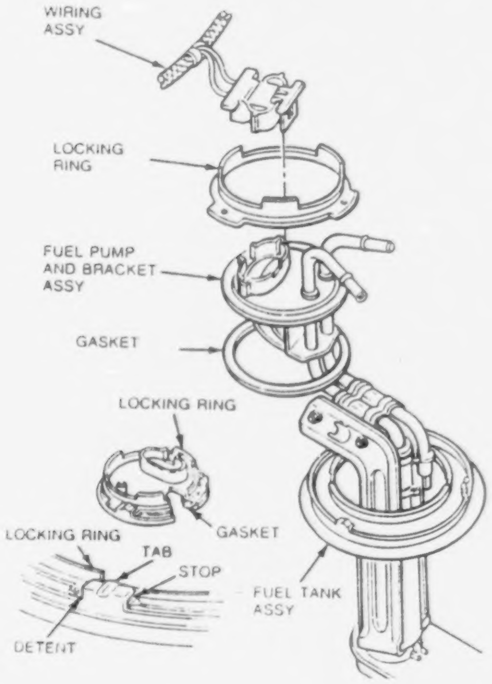
c. Drain and remove the fuel tank. (Removal is not necessary on all vehicles.)

d. Remove lock ring retaining pump assembly to tank.

e. Remove fuel pump from tank.

f. Install the fuel pump in reverse order of disassembly.

g. Replace fuel, start engine, and inspect system for leaks.



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MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR REMOVING AND REPLACING A FUEL TANK

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, year, engine size, and engine type (gas or diesel) of the vehicle to be serviced.
2. Develop a written procedure for safe removal of the fuel tank from the vehicle. Include procedure for safe removal and storage of the fuel. Also include all necessary specifications.
3. Develop a written procedure for removing the sending unit from the fuel tank. Include all necessary specifications.
4. Develop a written procedure for safely installing the fuel tank. Include all necessary specifications.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR TESTING MECHANICAL FUEL PUMP CONDITION

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual and the material provided in Lesson 2 of this Unit.)

1. Record the make, model, year, engine type (gas or diesel), and engine size of the vehicle to be serviced.
2. Develop a written procedure for testing fuel pump pressure. Include pressure specifications.
3. Develop a written procedure for testing fuel pump vacuum. Include vacuum specifications.
4. Develop a written procedure for testing fuel pump volume. Include volume specifications.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR ELECTRICAL FUEL PUMP TESTING

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual and the information provided in Lesson 2 of this unit.)

1. Record the make, model, year, engine type (gas or diesel), and engine size of the vehicle to be serviced.
2. Develop a logically written procedure for testing electrical fuel pump pressure. Determine and record fuel pump pressure specifications.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR GASOLINE ENGINE FUEL FILTER REPLACEMENT

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, year, engine size, and engine type (gas or diesel) of the vehicle to be serviced.
2. Develop a written procedure for removing and replacing the fuel filter. Include all necessary specifications.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR MECHANICAL FUEL PUMP REMOVAL AND REPLACEMENT

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, year, engine type (gas or diesel), and engine size of the vehicle to be serviced.
2. Develop a written procedure for removal of the fuel pump.
3. Develop a written procedure for installation of the fuel pump, including torque specifications. Include all necessary specifications.

JS1-L2-UI

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

FUEL TANK SERVICE

Equipment:

Fuel storage tank and siphoning equipment
Hand tools
Serviceable vehicle
Fuel sending unit wrench
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Place the vehicle securely on safety stands or lift with hoist. ___ ___ ___ ___

3. Disconnect the negative cable of the battery. ___ ___ ___ ___

4. Complete AS1-L2-UI. Following the procedures outlined in AS1-L2-UI, remove the fuel tank from the vehicle. ___ ___ ___ ___

   (**CAUTION:** Automotive fuel is highly flammable. Do not service fuel systems in the presence of sparks or open flame. Store fuel in approved sealed containers. Clean up any fuel spill immediately.)

   (**CAUTION:** Vehicles with in-tank electrical fuel pumps retain high pressure in the fuel system for long periods of time after the engine is shut off. This pressure must be removed before removing any fuel hoses. Consult the appropriate service manual before removing fuel lines.)

5. Following the procedure developed in item 3 of AS1-L2-UI, remove the fuel gauge sending unit from the fuel tank. ___ ___ ___ ___

   (NOTE: To prevent contaminants from entering the tank, clean any dirt and debris from the tank before removing the sending unit.)

6. Drain all remaining gas from the fuel tank into a container. Inspect the fuel for signs of dirt, water, rust, or other contaminants. Record the results below. ___ ___ ___ ___

7. Inspect the fuel tank for internal rust, large dents, holes, etc. Also inspect the condition of the filler cap, filler neck and fuel gauge sending unit. Record results below. ___ ___ ___ ___

8. Following the procedure developed in item 4 of AS1-L2-UI, install the fuel tank. Also install the fuel sending unit. — — — —

9. Lower the vehicle and refill the fuel tank. Reconnect the battery, connect exhaust ventilation equipment, start the engine and check for fuel leakage. Correct any leaks immediately. Shut off engine and disconnect exhaust ventilation equipment. — — — —

(**CAUTION**: Be sure to use approved exhaust ventilation equipment when operating a vehicle in an enclosed area.)

*Average of above evaluations — — — —

(*This average is a partial evaluation for Competency K2. Final evaluation for K2 will be made at the end of JS1-L2-UV.)

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

TESTING MECHANICAL FUEL PUMPS

Equipment:

Vacuum/pressure gauge
Hand tools
Graduated container
Serviceable container
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. If necessary, place the vehicle securely on safety stands or lift with hoist. ___ ___ ___ ___

3. Inspect the fuel pump for leakage and inspect the condition of hoses and lines. Record observations. ___ ___ ___ ___

4. Connect exhaust ventilation equipment, start vehicle and listen for unusual noise from pump. Note observations in the space provided below. Shut off engine. ___ ___ ___ ___

   (**CAUTION:** Be sure to use approved exhaust ventilation equipment when operating a vehicle in an enclosed area.)

5. Following the procedure developed in item 2 of AS2-L2-UI, test the fuel pump pressure. Record the gauge pressure in the spaces provided below. ___ ___ ___ ___

   (**CAUTION:** Automotive fuel is highly flammable. Do not service fuel systems in the presence of sparks or open flame. Store fuel in approved sealed containers. Clean up any fuel spill immediately.)

   Pressure noted______________________

   Specified pressure____________________

6. Following the procedure outlined below, perform a fuel pump vacuum test. _ _ _ _

   a. Complete question 3 of AS2-L2-UI.

   b. Using the procedure developed in question 3 of AS2-L2-UI, check the fuel pump vacuum.

   c. Record the results of the vacuum test in the space provided below.

   Vacuum noted on gauge________________

   Vacuum specified in service manual________________________________

7. Following the procedure outlined below, perform a fuel pump volume test. _ _ _ _

   a. Complete question 4 of AS2-L2-UI.

   b. Using the procedure developed in question 4 of AS2-L2-UI, perform the fuel pump volume test.

   c. Record the results of the test in the space provided below.

   Volume noted in test________________

   Specified volume____________________

8. Based on the tests, what is the condition of the pump? _ _ _ _

   OK_______ NOT OK_______

   Explain your answer in the space below.

9. Shut off engine, disconnect test equipment, restart engine and inspect for fuel leakage. Correct leakage immediately if found. _ _ _ _

10. Disconnect exhaust ventilation equipment. _ _ _ _

    *Average of above evaluations _ _ _ _

    (*This average is a partial evaluation for Competency K2. Final evaluation for K2 will be made at the end of JS1-L2-UV.)

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

ELECTRICAL FUEL PUMP PERFORMANCE TESTING

Equipment:

Appropriate pressure gauge
Proper adapters for pressure gauge
Hand tools
Serviceable vehicle
Safety glasses

Procedure:	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2. Inspect the condition of the fuel pump (if external) and attaching hoses. Record results in the space provided below.	__ __ __ __
3. Following the procedure outlined below, test the electrical fuel pump.	__ __ __ __

a. Complete AS3-L2-UI.

b. Connect exhaust ventilation equipment to vehicle exhaust when operating in an enclosed area.

(**CAUTION**: Be sure to use approved exhaust ventilation equipment when operating a vehicle in an enclosed area.)

(**CAUTION**: Automotive fuel is highly flammable. Do not service fuel systems in the presence of sparks or open flame. Store fuel in approved sealed containers. Clean up any fuel spill immediately.)

(**CAUTION**: Fuel injected vehicles with electrical fuel pumps retain high pressure in the fuel system for long periods of time after the engine is shut off. This pressure must be relieved before any fuel hoses are removed. Consult the appropriate service manual for proper procedure before removing fuel lines.)

c. Using the procedure developed in question 2 of AS3-L2-UI, test the fuel system pressure. Record results below.

Pressure noted____________________

Specified pressure________________

4. Shut off engine, relieve pressure and disconnect tester. _ _ _ _

5. Restart engine, check for fuel leakage and correct if found. _ _ _ _

6. Shut off engine and disconnect exhaust ventilation equipment. _ _ _ _

*Average of above evaluations _ _ _ _

(*This average is a partial evaluation for Competency K2. Final evaluation for K2 will be made at the end of JS1-L2-UV.)

JS4-L2-UI

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

FUEL FILTER REPLACEMENT

Equipment:

Hand tools
Serviceable vehicle
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. — — — —

2. If necessary, place the vehicle securely on safety stands or lift with hoist. — — — —

3. Following the procedure outlined below, replace the fuel filter. — — — —

    a. Complete AS4-L2-UI.

    b. Using the procedure developed in question 2 of AS4-L2-UI, replace the fuel filter.

    (**CAUTION**: Automotive fuel is highly flammable. Do not service fuel systems in the presence of sparks or open flame. Store fuel in approved sealed containers. Clean up any fuel spill immediately.)

    (**CAUTION**: Fuel injected vehicles with electrical fuel pumps retain high pressure in the fuel system for long periods of time after the engine is shut off. This pressure must be relieved before any fuel hoses are removed. Consult the appropriate service manual for proper procedure before removing fuel lines.)

4. Connect exhaust ventilation equipment, start vehicle and inspect for fuel leakage. If leakage is found, correct immediately. — — — —

    (**CAUTION**: Be sure to use approved exhaust ventilation equipment when operating a vehicle in an enclosed area.)

5. Shut off engine and disconnect exhaust ventilation equipment. — — — —

    *Average of above evaluations — — — —

    (*This average is a partial evaluation for Competency K2. Final evaluation for K2 will be made at the end of JS1-L2-UV.)

JS5-L2-UI

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

MECHANICAL FUEL PUMP REMOVAL AND INSTALLATION

Equipment:

Hand tools
Serviceable vehicle
Safety glasses

Procedure: Evaluation 3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. If required, place the vehicle securely on safety stands or lift with hoist. ___ ___ ___ ___

3. Following the procedure outlined below, remove the fuel pump from the vehicle. ___ ___ ___ ___

    a. Complete questions 1 and 2 of AS5-L2-UI.

    b. Using the procedure developed in question 2 of AS5-L2-UI, remove the fuel pump from the vehicle.

    (**CAUTION**: Automotive fuel is highly flammable. Do not service fuel systems in the presence of sparks or open flame. Store fuel in approved sealed containers. Clean up any fuel spill immediately.)

4. Thoroughly clean the pump mating surface on the engine. Inspect the fuel lines and hoses attaching to the pump. Replace any defective lines and hoses as directed by the instructor. In the space provided below, note any parts replaced. ___ ___ ___ ___

5. Following the procedure outlined below, install the fuel pump on the vehicle. ___ ___ ___ ___

    a. Complete question 3 of AS5-L2-UI.

    b. Using the procedure developed in question 3 of AS5-L2-UI, install the fuel pump.

    (NOTE: Be certain the pump lever is installed correctly or pump and/or engine damage may result when engine is started.)

6. Connect exhaust ventilation equipment to vehicle exhaust and start engine. Inspect for fuel leaks and correct immediately if found. — — — —

(**CAUTION**: Be sure to use approved exhaust ventilation equipment when operating a vehicle in an enclosed area.)

7. Shut off engine and disconnect exhaust ventilation equipment. — — — —

*Average of above evaluations — — — —

(*This average is a partial evaluation for Competency K2. Final evaluation for K2 will be made at the end of JS1-L2-UV.)

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT I: FUEL SUPPLY SYSTEMS

UNIT I TEST

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 1. Vapor lock is caused by liquid fuel which freezes fuel system components solid.

____ 2. The fuel tank is commonly constructed of corrosion resistant polyethylene.

____ 3. A restriction is installed in the filler neck of modern vehicles to prevent the introduction of leaded fuel.

____ 4. Leaded fuel will damage O_2 sensors.

____ 5. The fuel gauge sending unit is commonly attached to the fuel pickup tube.

____ 6. The fuel tank filter is commonly called a sock.

____ 7. Venting the fuel to the atmosphere causes a fire hazard as well as pollution.

____ 8. Today's vehicles have a domed shape tank which lowers the weed for venting.

____ 9. Excessive fuel vapors travel to the charcoal canister.

____ 10. Fuel systems are protected against leaks during rollover.

____ 11. Fuel lines may be made of steel, reinforced fuel resistant rubber or nylon hose.

____ 12. Some rubber fuel line hoses must withstand 50 or more psi.

____ 13. Gasoline engines usually have two filters.

____ 14. There are three basic types of in-line fuel filters.

____ 15. A mechanical fuel pump is driven by the crankshaft.

____ 16. Mechanical fuel pumps are most often found on vehicles built today.

____ 17. A fuel pressure regulator limits the amount of fuel that reaches the carburetor.

____ 18. Wire fuel tank mountings were commonly used on some vehicles.

____ 19. Always siphon as much fuel as possible from the tank before removing the tank.

____ 20. Most fuel tanks have some sort of drain plug.

____ 21. Disconnect the battery before removing the fuel tank.

____ 22. Fuel pressure must be released from fuel injected vehicles before repair.

____ 23. If rust is found on the inside of a fuel tank, the tank should be replaced.

____ 24. Fuel tanks should only be welded after they have been drained.

____ 25. Very little can be learned through visual inspection of the fuel filter.

SECTION B: Read each of the below statements made by Technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.

____ 26. TECHNICIAN I says that air in the fuel line can cause insufficient fuel delivery.

TECHNICIAN II says that new gas caps are of the pressure/vacuum variety.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 27. TECHNICIAN I says that baffles are installed in fuel tanks to prevent fuel vapors.

TECHNICIAN II says that the fuel pickup tube extends to the bottom of the fuel tank.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 28. TECHNICIAN I says that some fuel pumps are electric and placed inside the fuel tank.

TECHNICIAN II says that an electric pump cannot be installed in the tank because of the fire danger.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 29. TECHNICIAN I says that some fuel tanks have a separator to separate fuel from the atmosphere.

TECHNICIAN II says that fuel lines generally follow along the inside of the frame rail.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 30. TECHNICIAN I says that in-tank fuel filter is often called a sock.

TECHNICIAN II says that in-carburetor fuel filters are usually found on General Motors vehicles.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 31. TECHNICIAN I says that some fuel filters use a valve to prevent fuel leakage during a rollover.

TECHNICIAN II says that screw-in filters are used on most fuel injected engines.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 39. TECHNICIAN I says that the fuel tank often must be removed to replace the fuel pump.

TECHNICIAN II says that electric fuel pumps must be replaced if they show signs of leaking.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 40. TECHNICIAN I says that fuel tanks cannot be welded if they are damaged.

TECHNICIAN II says that most cars today use mechanical fuel pumps.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

(NOTE: The student must obtain a minimum score of _____ on the Unit I Test in order to receive an evaluation for Competency K2.)

____ 32. TECHNICIAN I says that vapor lock problems are more likely to occur to fuel systems with electrical fuel pumps.

TECHNICIAN II says that a fuel pressure regulator uses engine vacuum to control fuel line pressure.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 33. TECHNICIAN I says that a common rust point for fuel tanks is under the supporting straps.

TECHNICIAN II says that some states require the restrictor plate (for unleaded fuel) in the filler neck before the vehicle can pass safety inspection.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 34. TECHNICIAN I says the fuel sending unit often has to be replaced by using a special tool.

TECHNICIAN II says to check the sending unit float. See how the float floats in water.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 35. TECHNICIAN I says that small fuel tank leaks can be repaired by screwing a screw into the fuel tank hole with a neoprene washer used to seal the screw.

TECHNICIAN II says that before any fuel line work is performed on fuel injected vehicles, the fuel pressure must be removed from the lines.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 36. TECHNICIAN I says that a visual inspection of fuel filter can determine the quality of the filter.

TECHNICIAN II says always to check for fuel leaks after the fuel filter has been changed.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 37. TECHNICIAN I says that a manual fuel pump should be checked for pressure, vacuum, and the volume of fuel it delivers.

TECHNICIAN II says that most electric pumps should have a vacuum reading of at least 10 inches.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 38. TECHNICIAN I says to check filters and lines before changing the fuel pump if fuel volume output is low.

TECHNICIAN II says that, if a mechanical fuel pump is incorrectly installed, it could damage the pump and/or the engine.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

ANSWERS TO UNIT I TEST

1.	f	21.	t
2.	f	22.	t
3.	t	23.	t
4.	t	24.	f
5.	t	25.	t
6.	t	26.	c
7.	t	27.	d
8.	t	28.	a
9.	t	29.	b
10.	t	30.	c
11.	f	31.	a
12.	t	32.	b
13.	t	33.	c
14.	t	34.	a
15.	f	35.	c
16.	f	36.	b
17.	f	37.	a
18.	f	38.	c
19.	f	39.	c
20.	f	40.	d

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT II: CARBURETION

UNIT OBJECTIVE

After completing this unit, the student should be able to identify and describe the functions of various carburetor components. The student will demonstrate mastery of the material by achieving a score of ______ on the unit test.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the terms and definitions associated with carburetion (Competencies K1-K4, Unit II Test).

II. Identify the basic principles of carburetor operation (Competencies K1-K4, Unit II Test).

III. Identify the functions of the float circuit (Competencies K1-K4, Unit II Test).

IV. Identify the functions of the main metering circuit (Competencies K1-K4, Unit II Test).

V. Identify the functions of the idle circuit (Competencies K1-K4, Unit II Test).

VI. Identify the functions of the power enrichment circuit (Competencies K1-K4, Unit II Test).

VII. Identify the functions of the accelerator pump circuit (Competencies K1-K4, Unit II Test).

VIII. Identify the components and functions of the choke system (Competencies K1-K4, Unit II Test).

Lesson 2.

I. Identify the various types of carburetors (Competencies K1-K4, Unit II Test).

II. Identify the various carburetor control devices and their functions (Competencies K1-K4, Unit II Test).

III. Identify the principles of electronic feedback carburetion (Competencies K1-K4, Unit II Test).

IV. Identify the purpose and design of intake manifolds (Competencies K1-K4, Unit II Test).

ASE TASKS COVERED IN THIS UNIT

I. Only material that is preliminary to ASE tasks appears in this unit; therefore, no ASE tasks are covered directly.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT II: CARBURETION

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

   1. Lesson 1: CARBURETOR FUNDAMENTALS

      a. Information outline

      b. Assignment sheet

         AS1-L1-UII: Carburetor Fundamentals

   2. Lesson 2: CARBURETOR DESIGNS AND CONTROLS

      a. Information outline

      b. Assignment sheet

         AS1-L2-UII: Carburetor Designs and Controls

E. Unit test

F. Answers to unit test

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NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

   1. Students should do AS1-L1-UII and AS1-L2-UII before taking the Unit II Test.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT II: CARBURETION

LESSON 1: CARBURETOR FUNDAMENTALS

I. Terms and definitions

   A. Air horn--The upper portion of a carburetor.

   B. Atomization--Refers to the breaking up of the fuel into small particles and their mixing with air.

   C. Dieseling (run-on)--Term used to describe an engine that keeps running after the ignition is turned off. Usually caused by an idle speed that is too fast.

   D. Flooding--Refers to a condition in which the air/fuel mixture is too rich.

   E. Lean--Refers to an air/fuel mixture that does not have adequate fuel.

   F. Rich--Refers to an air/fuel mixture that has too much fuel.

   G. Starving--An air/fuel mixture that is far too lean.

   H. Throat--The passage in a carburetor through which the flow of air and fuel passes. Flow of air is controlled by the throttle valve at the bottom of the carburetor throat.

   I. Throttle--The mechanism that controls the position of the throttle valve.

   J. Throttle valve--A valve in the lower part of the carburetor throat. The throttle valve controls the flow of air through the carburetor.

   K. Venturi effect--The lowering of air pressure as a result of an increase in air velocity. In the venturi effect, air velocity increases as it passes through a restrictor (venturi).

   L. Vaporization--The process of liquid fuel turning into a gas (vapor).

II. Basic principles of carburetor operation

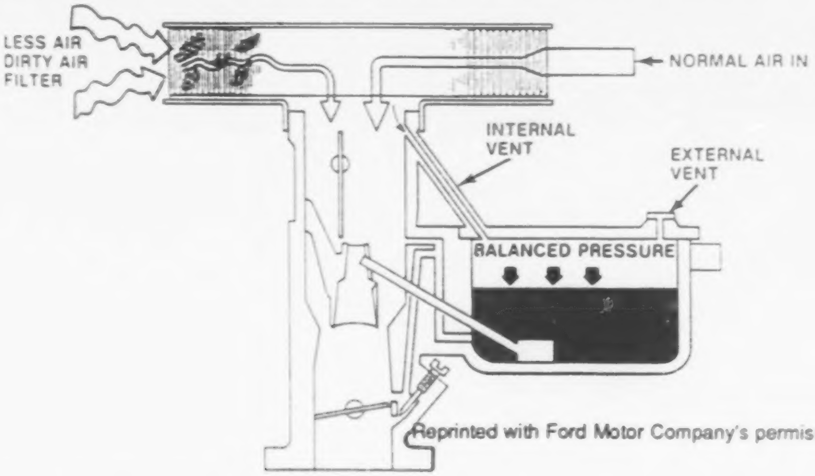
   A. The carburetor is a device that mixes fuel and air in the proper proportions for delivery to the engine. If an engine were to run at a set speed and load at all times, a carburetor would be a very simple device. However, the speed and load of an automobile engine are continuously changing. In addition to handling changing engine load and speed, modern automobile carburetors must help the engine meet today's strict auto emission standards. Because of this wide range of demands, the carburetor is a very complex device. There are six basic circuits in a carburetor.

   B. Some carburetors have other circuits, depending on design.

III. Carburetor float circuit

   A. The float circuit controls the entrance of fuel into the carburetor and determines the level of fuel in the fuel bowl. The float system isolates the carburetor fuel bowl from fuel pump pressure and keeps the fuel in the bowl at a constant level. The level of the fuel in the float bowl is kept at a constant level by the rising and falling of the float in the bowl. Components of the float circuit are: the float, the float bowl, the fuel inlet fitting, the float inlet needle valve and needle seat, and the float bowl vent.

1. Early floats were constructed of hollow brass. Most floats today are constructed of nitrile rubber; however, some are constructed of brass or hollow plastic. A metal arm attached to the float controls the opening and closing of the inlet needle valve. This arm can be adjusted to change float height. All fuel metering passages originate from the float chamber. For this reason, proper float adjustment and corresponding fuel level are very important to the operation of all circuits.



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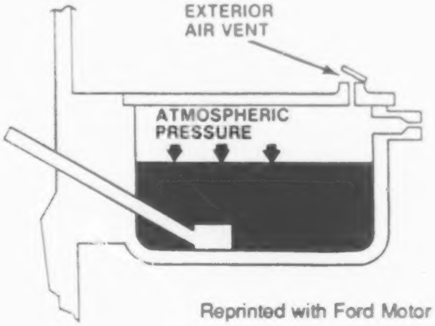
2. The float bowl may be an integral part of the main carburetor body or may be a separate part that is attached to the main carburetor casting. Float bowls are generally made of cast aluminum, but plastic float bowls are not uncommon. A bowl cover seals the float chamber.

3. The fuel inlet fitting may be a brass fitting that threads into the carburetor or may be cast directly into the carburetor. The inlet fitting sometimes contains a fine screen to help filter out impurities. The inlet fitting and the float needle seat are sometimes integral with each other.

4. The float inlet needle valve and needle seat are generally made of brass. The inlet needle and seat close the entrance of fuel into the float bowl by the action of the float. The needle sometimes has a viton rubber tip to aid in sealing.

5. The float bowl vent is an internal vent, which extends into the throat of the carburetor. Early carburetors had an external vent that vented fuel vapors directly to the atmosphere. Carburetors now vent externally to a charcoal canister. As will be described later, the float bowl must be vented to the atmosphere in order for the carburetor to function.



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B. Operation of the float system

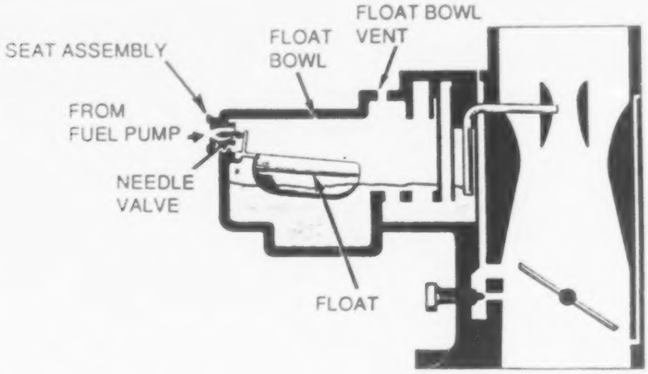
1. Fuel enters the carburetor through the inlet fitting. As the float bowl fills, the float begins to rise.

2. When the float reaches a height predetermined by the adjustment of the float arm, the float applies force to the fuel inlet needle.

3. The inlet needle is forced against the inlet needle seat and fuel flow into the carburetor stops.

4. Fuel will be prevented from entering the float bowl until the level of fuel in the bowl drops, lowering the float and allowing fuel to flow past the needle valve.

(NOTE: Some carburetor designs may have two float bowls.)

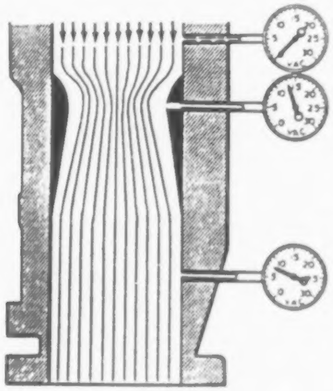


IV. Main metering circuit of the carburetor

A. The main metering circuit provides air/fuel mixtures for most normal driving conditions from low-speed, partial throttle to wide-open throttle.

B. The main metering system consists of the main metering jet, the main well tube, the main well, an air bleed, and a discharge nozzle.

C. A restriction tube called a venturi is located inside the throat of the carburetor. Carburetors usually have a main venturi and a booster venturi. The restriction created by the venturi serves to increase airflow velocity. The increased velocity causes the air pressure to drop, which, in turn, causes fuel to flow from the fuel bowl.



NOTE HOW VACUUM VARIES THROUGH DIFFERENT SECTIONS OF THE CARBURETOR.

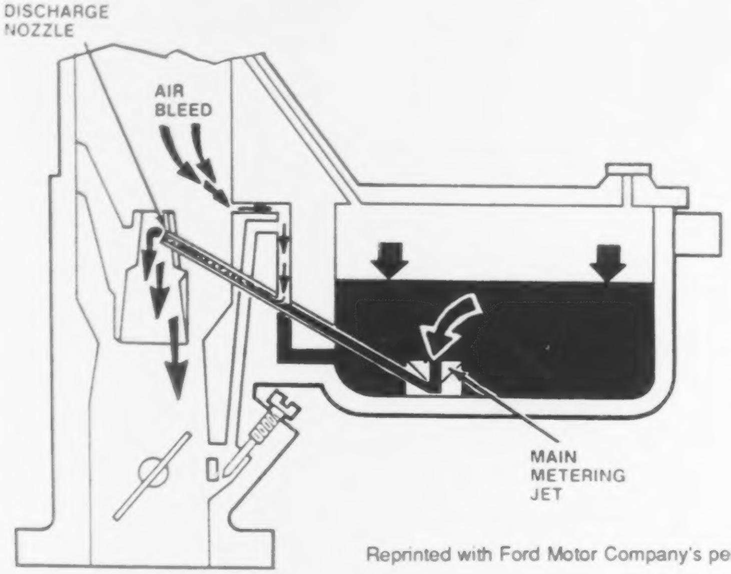
D. Operation of the main metering circuit

1. During closed-throttle operation, an idle circuit controls fuel flow. As the throttle opens and airflow increases through the venturi, the main metering system takes over.

2. As pressure drops in the venturi, atmospheric pressure is applied through the bowl vent to the fuel in the bowl. Atmospheric pressure forces fuel through the main metering jet and into the main well.

3. In the main well, air is mixed with fuel. The air bleed prevents a vacuum from forming in the main well as fuel flows up the main well tube. At this point, the fuel begins to undergo atomization.

4. Fuel flows from the main well tube and out of the discharge nozzle located in the venturi.



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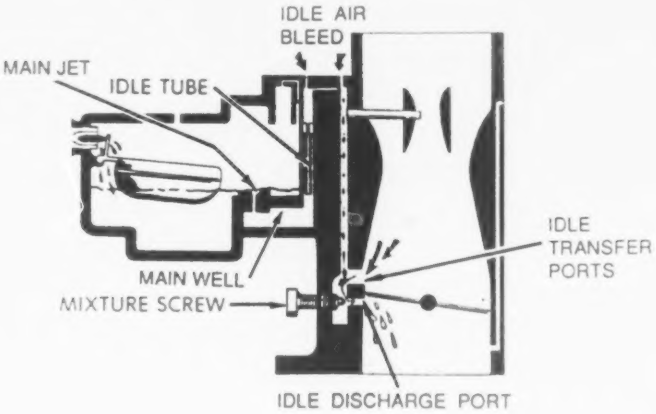
5. As fuel enters the main air stream, it is further atomized. The fuel must be atomized so it will vaporize more easily. Liquid fuel must be changed to vapor to achieve ignition.

6. Fuel flow out of the discharge nozzle is regulated by the amount the throttle is opened. The more the throttle is opened, the greater the airflow; the greater the airflow, the greater the fuel flow. Fuel flow from the float bowl is limited by the size of the main metering jet.

V. Idle circuit

A. The idle circuit delivers air/fuel mixture below the carburetor throttle at idle and above the throttle during the transition to the next circuit. This system typically consists of the main metering jet, idle well and idle tube, idle air bleed, idle transfer slot, idle mixture adjusting screw, idle discharge port, and a restrictor.



B. Operation of the idle circuit

1. Intake manifold vacuum creates a low pressure at the idle discharge port.

2. Atmospheric pressure in the fuel bowl pushes fuel through the main jet, the idle well, and the idle tube up to the idle air bleed. At this point air is mixed with the low pressure fuel.

3. From the air bleed, a mixture of air and fuel flows down past the transfer slot.

    a. At curb idle when the throttle is closed, additional air enters the transfer slot from above the throttle valve.

    b. From here the mixture flows out of the idle discharge port.

    c. A mixture adjustment screw enables the technician to adjust the amount of fuel flowing into the engine from the idle port. On late-model vehicles, the idle mixture screw is set at the factory and then sealed to prevent tampering. Adjustment can be accomplished, however, if it becomes necessary. This procedure will be discussed in a later lesson.

    d. On late-model vehicles, the mixture is restricted by a calibrated orifice called an idle restrictor. This limits the amount the mixture that can be richened by turning the mixture adjusting screw.

    e. As the throttle is opened, low pressure is exposed to the transfer port or slot. Additional air/fuel mixture sprays from the transfer port to provide a smooth transition from idle to higher speed circuits. The idle mixture adjustment screw continues to meter fuel during the transition period.

VI. Power enrichment circuit

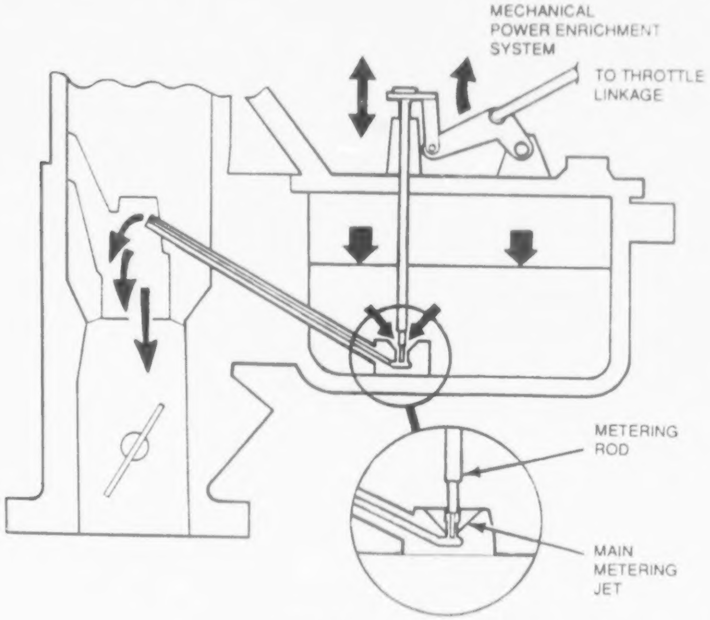
A. As speed and engine load increase, the engine will require more fuel. The maximum fuel flow from the main metering system is limited by the fixed main metering jet; therefore, the main metering system cannot provide the additional fuel needed during high engine demand. The power enrichment system provides this extra fuel.

B. Components of the power enrichment system vary somewhat, depending on the manufacturer.

1. One type of enrichment system uses a special tapered metering rod.

    a. In this system, the metering rod is placed in the main metering jet. During normal operation, the metering rod is positioned low in the jet, restricting maximum fuel flow. When the throttle is opened wide, the metering rod is raised, allowing additional fuel to flow.

    b. Metering rods are controlled either by a mechanical linkage connected to the accelerator linkage or a vacuum-actuated mechanism, which lifts the metering rods.



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2. Another type of enrichment system uses a vacuum-operated power valve.

    a. The vacuum-operated power valve consists of either a vacuum diaphragm or piston which actuates a spring-loaded valve.

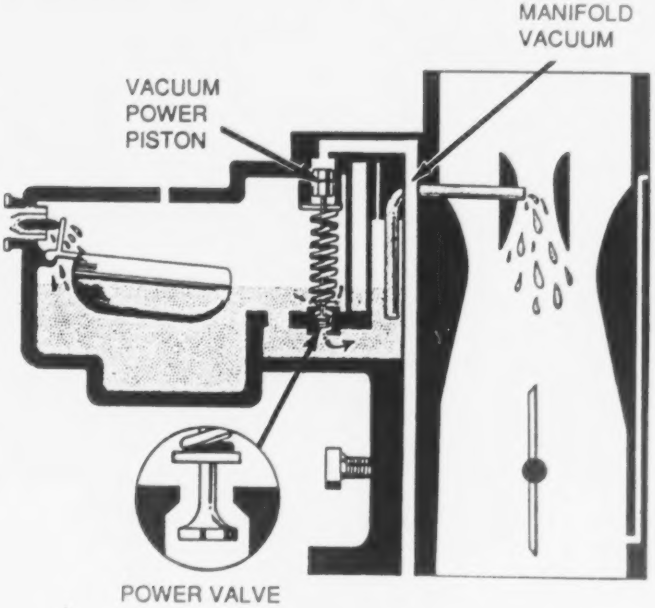
    b. A typical power piston system consists of a power valve that is closed by spring loading.

    c. When manifold vacuum is high, it holds the vacuum-operated power piston in the up position against spring pressure.

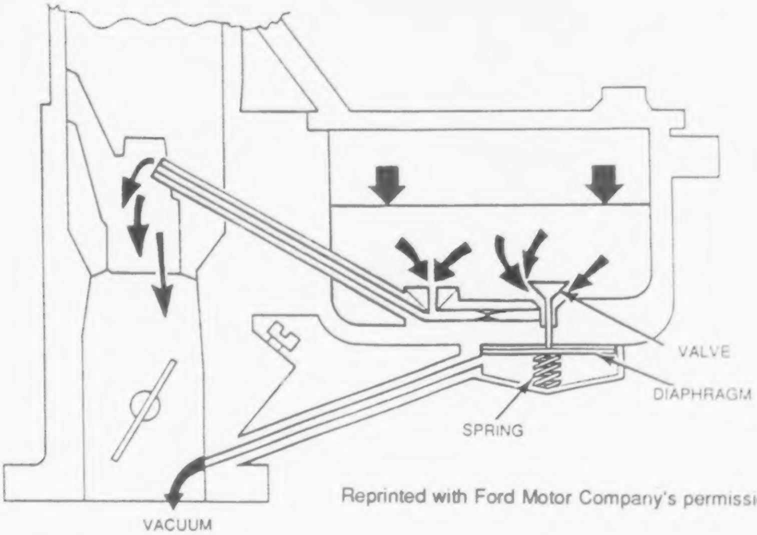
    d. When the driver accelerates and opens the throttle to a point at which intake manifold vacuum drops, a calibrated spring on the piston forces the piston downward.

e. The downward movement of the piston forces the power valve open. This allows additional fuel to be admitted to the engine through the main discharge nozzle.

f. When the driver lets off the accelerator, intake manifold vacuum rises and overcomes the spring pressure on the power piston. The piston then rises and the power valve closes.


MANIFOLD VACUUM
VACUUM POWER PISTON
POWER VALVE

(NOTE: Operation of the piston system is very similar to operation of the diaphragm system.)


VALVE
DIAPHRAGM
SPRING
VACUUM

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VII. Accelerator pump circuit

A. During acceleration, an accelerator pump is needed to add an additional "shot" of fuel to prevent hesitation or lag. When the throttle is opened, there is an immediate increase in volume of entering air. Fuel, however, is heavier than air and, therefore, does not move as quickly as air. During quick acceleration the fuel mixture will, for a moment, be too lean. The accelerator pump provides the additional fuel needed until the carburetor can respond to the change in throttle opening and provide the correct air/fuel mixture.

B. A typical accelerator pump circuit consists of a pump plunger and a stem which are operated by a mechanical linkage attached to the throttle linkage. An inlet and outlet check valve and a pump discharge nozzle are also included in the system.

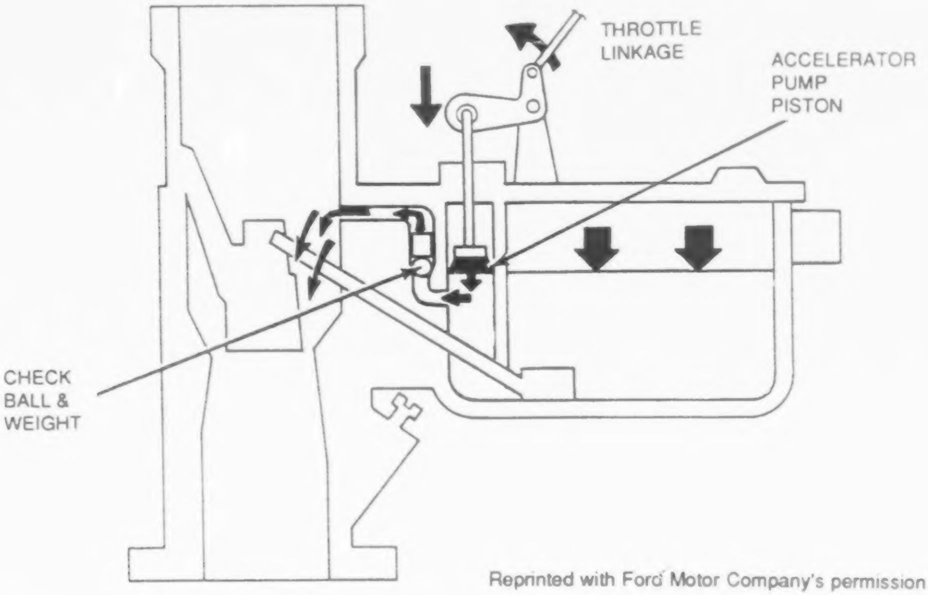
C. Operation of the accelerator pump circuit

1. The accelerator pump travels in a cylinder that is filled with gasoline through a passage connected to the float bowl.

2. When the throttle is opened, mechanical linkage forces the accelerator pump down in its bore. This action forces an inlet check ball (valve) closed to prevent fuel from flowing back into the fuel bowl. The inlet check is sometimes built into the pump plunger cup.

3. Fuel is forced by the pump through a passage to a discharge nozzle in the carburetor throat.

4. Fuel pressure unseats a discharge check ball located in the discharge passage. The discharge check ball is used to prevent the venturi effect from continuously discharging from the accelerator pump nozzle.


THROTTLE LINKAGE
ACCELERATOR PUMP PISTON
CHECK BALL & WEIGHT

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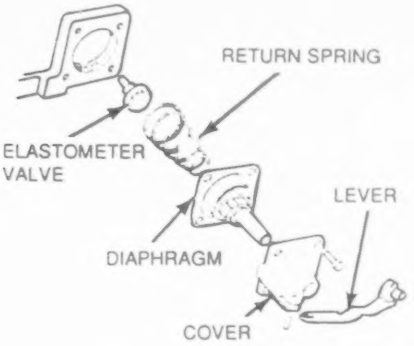
(NOTE: Some carburetors use a diaphragm pump instead of a plunger pump. Operation of the diaphragm pump is very similar to that of the plunger pump.)


RETURN SPRING
ELASTOMETER VALVE
LEVER
DIAPHRAGM
COVER

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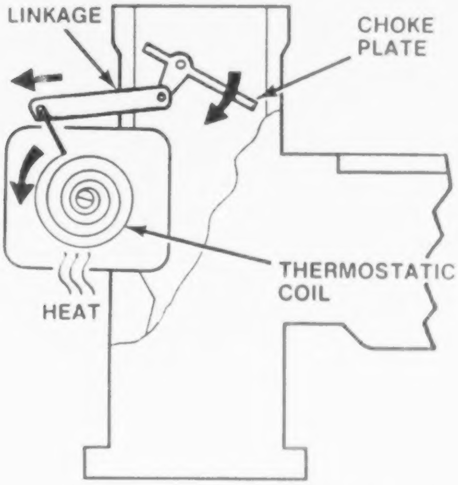
VIII. Choke system

A. The purpose of the choke system is to enrich the fuel mixture for all carburetor circuits during cold start and warm-up periods. During cold engine operation, the fuel does not vaporize as easily and, therefore, a richer mixture is required to achieve ignition.

B. Components

1. Choke systems for modern automobiles consist of a choke plate that shuts off most airflow through the carburetor when the engine is cold. The choke plate is located at the top of the carburetor air horn.

2. A thermostatic bimetal spring is used to control the opening and closing of the choke plate. The bimetal spring is mounted either on the carburetor or in a well in the intake manifold. When engine temperature is cold, the bimetal spring winds up and closes the choke plate. As the engine warms up, the spring unwinds and opens the choke plate.


LINKAGE
CHOKE PLATE
THERMOSTATIC COIL
HEAT

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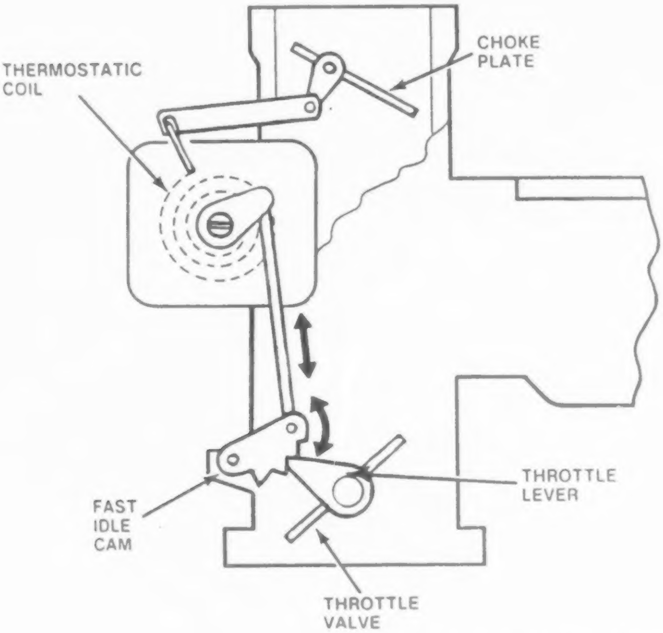
3. A fast idle linkage is connected from the bimetal spring to the accelerator linkage. This fast idle linkage provides for a higher idle speed when the choke is "on" and maintains the speed until the engine warms up. The higher idle speed prevents stalling.


THERMOSTATIC COIL
CHOKE PLATE
THROTTLE LEVER
FAST IDLE CAM
THROTTLE VALVE

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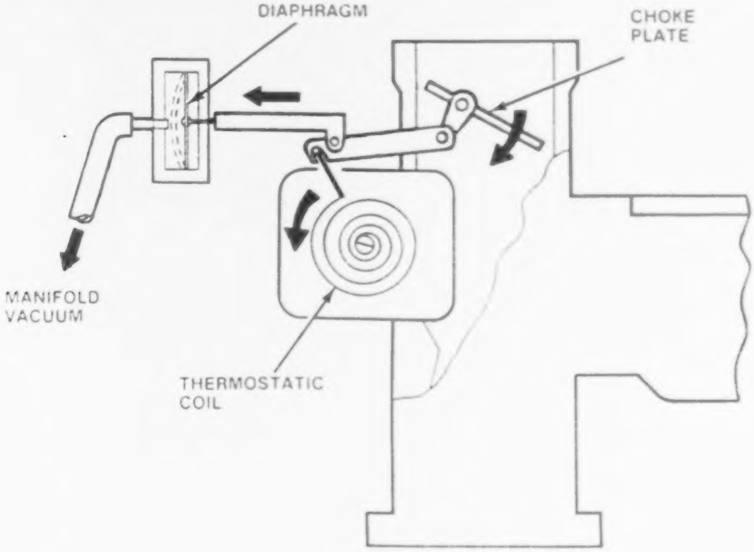
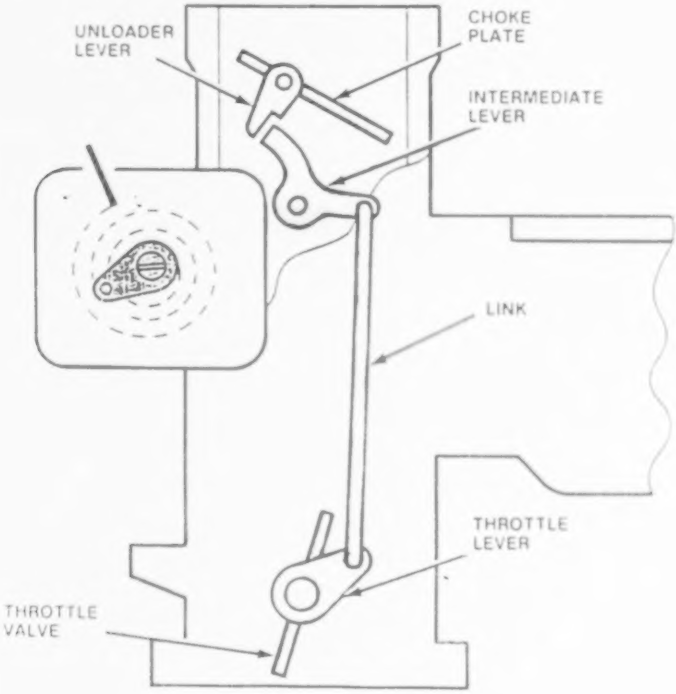
4. The choke pulloff (vacuum break, vacuum kick) is a vacuum diaphragm or piston connected by a linkage to the choke plate. When the engine starts, manifold vacuum applied to the pulloff causes the choke plate to open a predetermined amount. This prevents flooding.


DIAPHRAGM
CHOKE PLATE
MANIFOLD VACUUM
THERMOSTATIC COIL

5. The choke unloader is a feature built into the choke linkage to "deflood" the engine. By pressing the accelerator all the way to the floor, the choke is forced open a predetermined amount. The flooded engine can then be cranked and started.


UNLOADER LEVER
CHOKE PLATE
INTERMEDIATE LEVER
LINK
THROTTLE LEVER
THROTTLE VALVE

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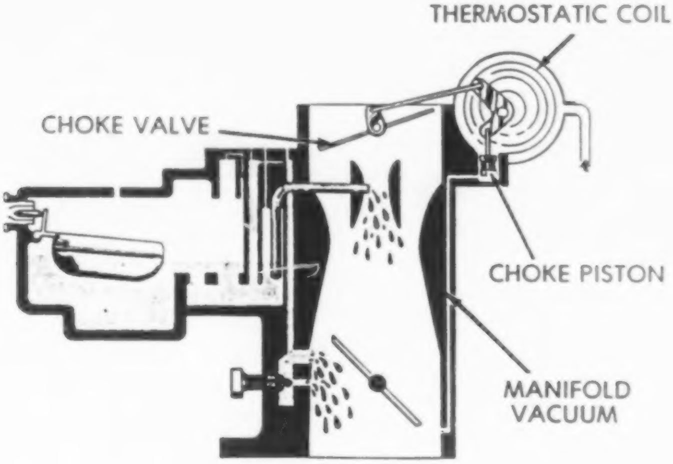
6. On modern automobiles, a choke heating element warms up the choke. When the engine is started, voltage is applied to a resistance type heating element that warms the bimetal spring and opens the choke plate.

C. Operation of the choke system

(NOTE: Early automobile choke systems consisted of a choke plate which was opened and closed by a cable that extended into the passenger compartment. Many trucks still use this type of choke system. However, the operation of the choke system in most of today's vehicles is far more complex.)

1. The bimetal choke spring closes the choke plate when engine temperature is low. the closing of the choke plate creates low pressure high in the throat of the carburetor just under the choke plate. This low pressure causes fuel discharge from the main metering circuit of the carburetor and thus creates a rich fuel mixture.



2. As soon as the engine starts, vacuum is applied to the choke pulloff. This opens the choke just enough to prevent the engine from flooding.

3. After the engine starts, the bimetal spring is heated and thus allows the choke to begin to open. Heating of the choke element can be accomplished in a variety of ways, two of which are identified below.

   a. An electric heating element can be used to heat the bimetal spring after the engine is started to open the choke.

   b. Heat from the exhaust system can be used to heat the bimetal spring. It should be noted, however, that the spring does not make direct contact with the exhaust.

   c. Engine coolant can be used to heat the bimetal spring. Engine coolant is directed through a passage past the bimetal spring. As the coolant warms, it heats the spring. The coolant never comes into direct contact with the bimetal spring.

4. A fast idle linkage provides a faster-than-normal idle speed during cold engine operation. This faster idle speed overcomes cold engine friction and stalling after starting.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

CARBURETOR FUNDAMENTALS

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. List the six basic carburetor circuits.

2. What device is placed in the carburetor throat to speed airflow?

3. What device is used to enrich the air/fuel ratio during cold engine operation?

4. What pump is used to prevent engine hesitation during acceleration?

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

CARBURETOR FUNDAMENTALS

(ANSWER SHEET)

1. Float, power enrichment, main metering, accelerator pump, idle circuit, choke
2. Venturi
3. Choke
4. accelerator pump

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT II: CARBURETION

LESSON 2: CARBURETOR DESIGNS AND CONTROLS

I. Carburetor types

A. The carburetors that have been described thus far are the "single-barrel" type. The single-barrel carburetor contains a single throttle and choke plate and a single throat (air horn) and venturi cluster. In addition to the single-barrel carburetors, automobiles can use two- or three-, and even four-barrel carburetors.

B. Two-barrel carburetors may be either single-stage or two-stage.

1. In a single-stage carburetor, both throttle valves open and close at the same time. Both barrels share the same idle, main metering system, along with other systems.

2. In two-stage carburetors, each barrel has a separate function. The primary barrel controls idle, off-idle, and lower cruising speeds. The secondary barrel does not start opening until the accelerator is opened further and more fuel and air are needed. The secondary barrel generally has only a main metering system. The secondary barrel may be controlled by either a mechanical linkage or by a vacuum diaphragm.

C. Three- and four-barrel carburetors are two-stage carburetors. Two primary barrels function together to provide choke, idle, main metering, etc. The secondary barrel or barrels provide additional air and fuel in high-demand situations. The secondary barrel or barrels may be operated either mechanically or by vacuum.

D. All the carburetors discussed thus far have been the fixed venturi type. A different type of carburetor is the variable venturi type. The variable venturi carburetor varies the area of the venturi as a function of speed and load.

1. On fixed venturi carburetors, circuits (such as idle and power circuits) are added to handle the variations in airflow through the carburetor. At low engine rpm, there is not enough air flowing through the carburetor to make the conventional fixed venturi work; therefore, the fixed venturi carburetor must use an independent idle system. In low-manifold vacuum acceleration, the fixed-venturi carburetor must use a power valve.

2. The variable venturi carburetor, however, is able to change the size of the venturi to maintain a sufficient air velocity and pressure drop for the main metering system. Below is a description of how the variable venturi carburetor operates.

a. Tapered metering rods are attached to the venturi valve (the device that changes the size of the venturi). There is one metering rod and jet for each bore of the carburetor.

b. The rod moves back and forth in the jet when the air valve moves.

c. When the venturi valve is closed, the part of the rod with the largest diameter is in the jet.

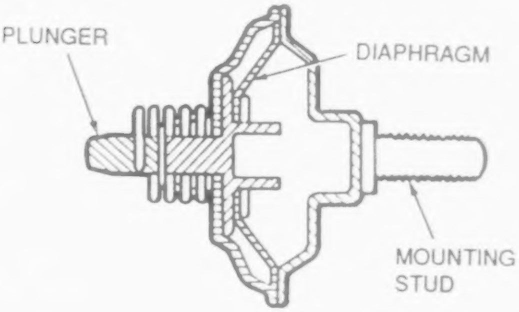
d. When the air valve is in the wide-open position, the part of the rod with the smallest diameter is in the jet.

e. Effective metering of the fuel is controlled by the rod position and the jet.

II. Other carburetor systems and controls include the following: the dashpot; the altitude compensator; the solenoid; the idle control; the hot idle compensator; and the electronic idle speed control.

A. The dashpot is a device that slows the closing of the throttle. The dashpot prevents stalling that may occur during deceleration. The dashpot consists of a small chamber with a spring-loaded diaphragm and plunger. Below is a description of the operation of the dashpot.

1. Shortly before it closes, the throttle comes into contact with the dashpot plunger.
2. As the throttle exerts force on the dashpot plunger, air is slowly forced out of the diaphragm chamber through a bleed hole.
3. The slow escape of air slows the throttle closing.



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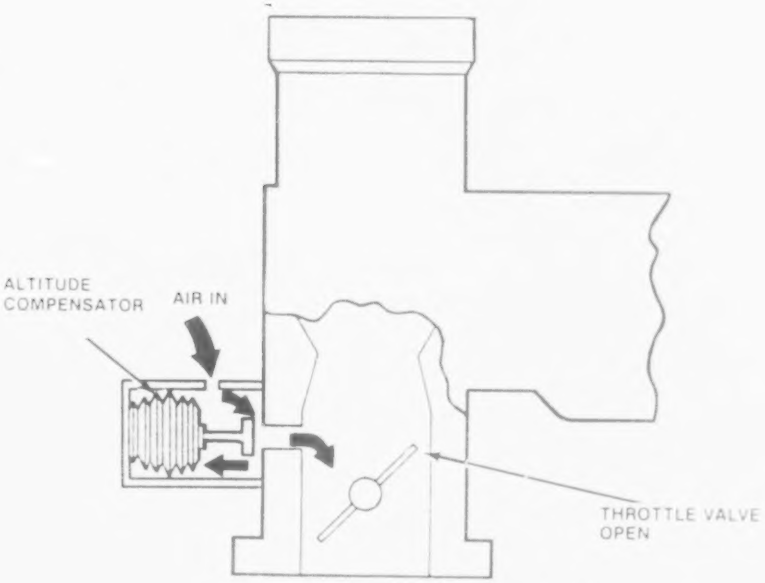
B. Driving in high altitudes, which have thin air, may cause an ordinary carburetor to produce a fuel mixture that is too rich. Some vehicles are, therefore, equipped with a device to compensate for the thin atmosphere by making the fuel mixture leaner. Below is a description of a typical altitude compensator found in a Carter Thermoquad carburetor.

1. A small, cylindrical bellows chamber is mounted on the front of the carburetor and is vented directly to the atmosphere. Changes in atmospheric pressure will either expand or contract the bellows.
2. Airflow is regulated by a small, brass, tapered-seat valve, which is lifted off its seat by the expanding bellows.
3. A small spring is positioned on top of the tapered valve (the valve is located between the valve and housing). The function of the spring is to help maintain the valve in the closed position when the system is exposed to marginal pressure and mechanical vibrations, which might unseat the valve at the improper time.

   (NOTE: Marginal pressure would be too low to hold the valve firmly closed but not low enough to cause the valve to open completely.)

4. Air that is too thin expands the bellows, thus supplying extra air to the primary main air bleeds. (Air from the bellows moves through a calibrated orifice, which meters the proper amount of air to the air bleed.)

5. The extra air maintains the correct air/fuel mixture. The system supplies varying amounts of additional air, depending upon different altitudes. When sufficient atmospheric pressure is again restored, the valve closes and the system returns to its normal mode of operation.



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C. The idle control solenoid controls idle speed by maintaining a preset idle position when the solenoid is engaged. The solenoid has a plunger that extends when electrical current is applied.

1. The solenoid holds a set throttle position until the ignition is turned off, at which time the solenoid disengages and the throttle closes further to prevent dieseling.

2. The solenoid also compensates for engine loads, such as those created by the air conditioner. When the air conditioner (or some other device) puts an extra load on the engine, the solenoid engages and opens the throttle further. The greater throttle opening maintains an acceptable idle speed while the engine is under the extra load.

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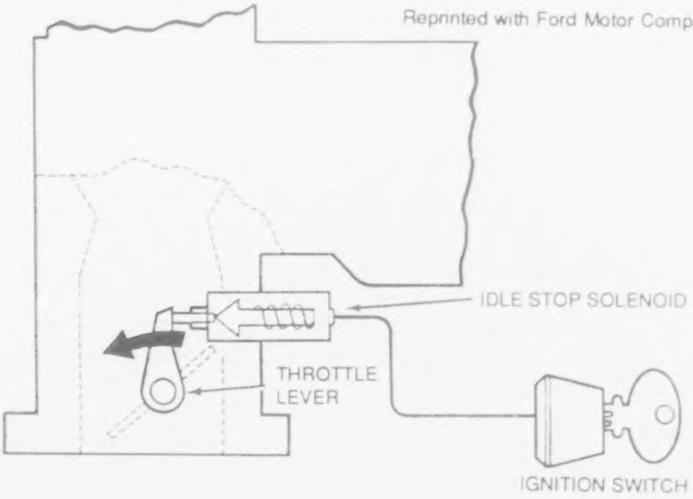
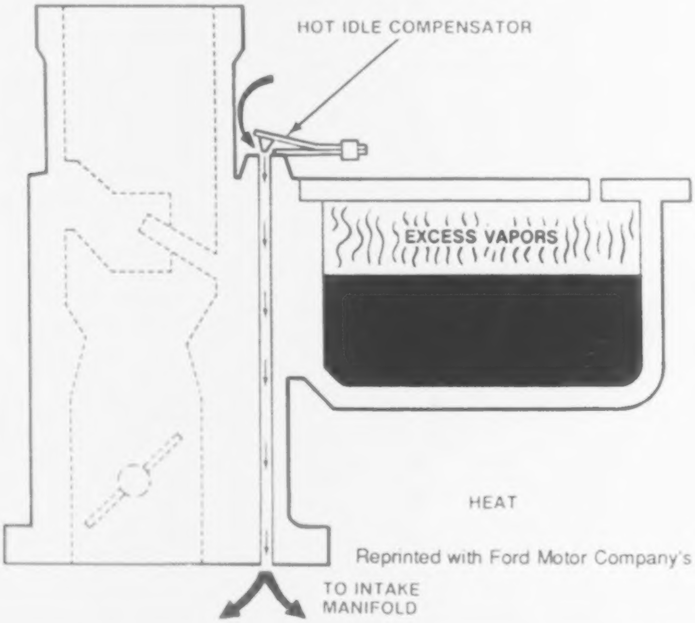


D. When the engine overheats, the hot idle compensator opens an air passage to make the fuel mixture leaner. The additional air raises idle speed and increases coolant flow, which helps cool the engine. The fuel in the carburetor tends to vaporize excessively when the engine overheats, causing the carburetor to flood. The additional air also leans the mixture slightly to help reduce flooding. The hot idle is commonly constructed by using a bimetal strip that bends to open an air bleed when temperature is high.



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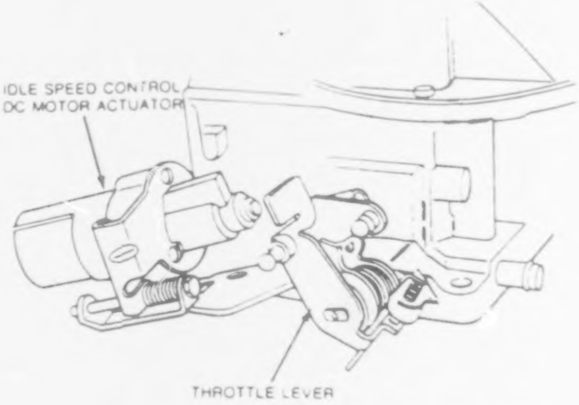
E. Some carbureted vehicles that use an electronic control module (ECM) to control certain engine functions also incorporate an idle speed control (ISC). The ISC uses a reversible electric motor to maintain a selected idle speed, regardless of the load imposed upon the engine. The ISC system relies on inputs from various sensors to keep the idle at the proper speed. Below is a description of the operation of the ISC.



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1. The ECM uses a temperature sensor to determine the temperature of the engine coolant. When the coolant is cold, the ECM signals the ISC motor to provide a higher idle speed.

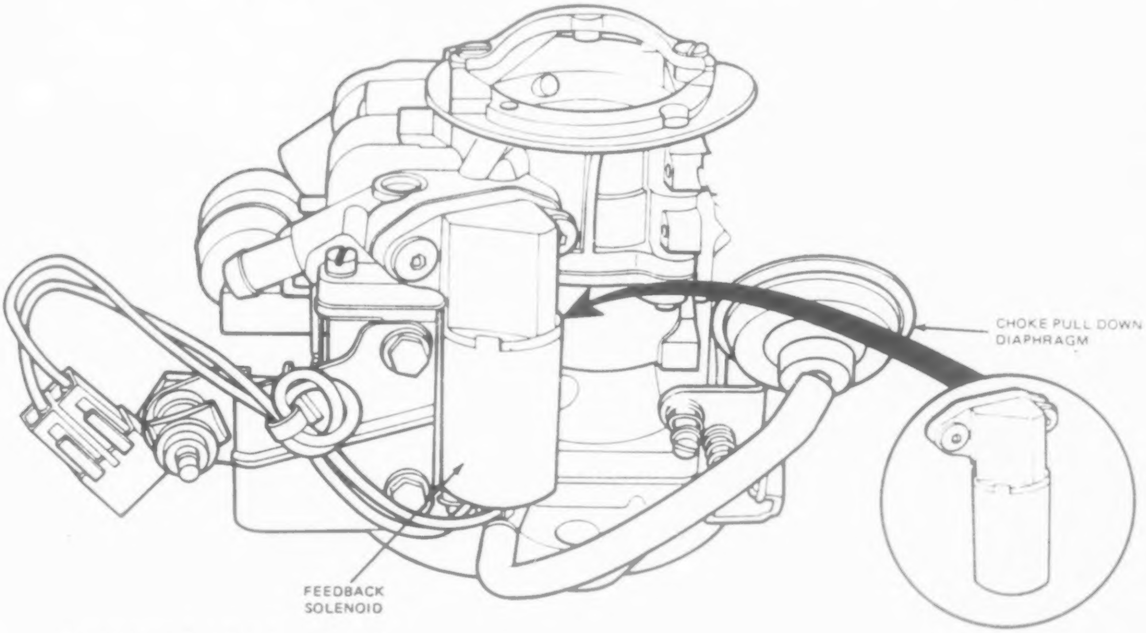
2. The distributor relays the engine rpm to the ECM. The ECM then signals the ISC either to increase or decrease the idle speed based on engine rpm.

3. The ISC motor incorporates a throttle switch that tells the ECM whether or not the throttle lever is resting on the ISC plunger. When the throttle is resting on the plunger, the ECM controls the idle speed. If the throttle lever is away from the plunger, the operator of the vehicle will control the idle speed.

4. When the air conditioner is running, a signal from the air conditioner clutch causes the ECM to signal the ISC to raise idle speed.

5. The ECM also senses battery voltage. If the voltage falls below a predetermined level, the ECM tells the ISC to increase idle speed. The increase in idle speed increases generator output.

6. A park-neutral switch notifies the ECM of a transmission gear change. The ECM then signals the ISC to set idle speed at a level appropriate for the gear change.



III. Electronic feedback carburetion

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A. Development of electronic feedback carburetion

1. Electronic feedback carburetion is a system that allows for more efficient combustion through electronic control of the air/fuel mixture. With the advent of the three-way catalytic converter (to be discussed in a later unit), a very precise method of controlling air/fuel ratios was needed.

2. Prior to the late 1970's, catalytic converters were used to control the output of hydrocarbons and carbon monoxide. Three-way catalysts lower the output of hydrocarbons, carbon monoxide and oxides of nitrogen. But to accomplish this task, an air/fuel ratio very close to the stoichiometric (14.7 to 1) ratio must be maintained. A system using a sensor (an O_2 sensor) in the exhaust to monitor the presence of oxygen was developed for this purpose.

B. Operation of the O_2 sensor system

1. The O_2 sensor produces voltage signals in accordance with the amount of oxygen in the exhaust and sends electrical signals to the ECM.

2. The ECM interprets the signals from the O_2 sensor along with other inputs and adjusts the fuel mixture accordingly.

3. When all the sensors are working together with the ECM to control the air/fuel mixture, the system is said to be in "closed loop." The opposite condition, called "open loop," occurs when the system is operating at a fixed setting and is not subject to change due to sensor input.

4. Changes in fuel mixture are accomplished through the use of a mixture control solenoid in the carburetor.

C. Mixture control solenoid (also called O_2 solenoid or duty cycle solenoid)

1. Two types of mixture control solenoids are commonly found on passenger cars: the fuel-control type and the air-bleed type. A vacuum-operated feedback control was also used on some early feedback units.

2. The fuel-control type mixture control solenoid is an electrical device that controls fuel flow from the float bowl to the main well and, at the same time, controls an idle circuit air bleed. Below is a description of the mixture control-type solenoid.

   a. The solenoid includes a fuel-control valve that enriches fuel delivery to the idle/low-speed and main metering passages.

   b. The solenoid also controls an air-bleed passage in the upper part of the assembly.

   c. The carburetor air horn contains a fixed air bleed. The upper solenoid valve controls the flow of air through internal passages aligned with the air horn.

   d. When the solenoid plunger is depressed, the fuel control valve decreases fuel flow and the air bleed increases airflow. Both operations produce leaner mixtures.

   e. With the solenoid plunger raised, the fuel control valve opens and the air bleed closes. These simultaneous operations enrich the mixtures.

3. The air-bleed type solenoid is a simpler design that opens and closes an air bleed. When open, the air bleed supplements air entry to the idle/low-speed and main metering passages for leaner mixtures.

   (NOTE: Both the fuel-control type and the air-bleed type solenoids are energized by completing a ground circuit inside the ECM. In both types of solenoids, when voltage is applied, the solenoid makes the air/fuel mixture leaner. The computer controls how long the mixture control solenoid is energized. In this way the computer controls carburetor air/fuel ratio.)

D. Duty cycle of the mixture-control solenoid

(NOTE: The term duty cycle refers to the length of time the mixture control solenoid is energized.)

1. In operation, the mixture control solenoid opens and closes 10 times per second. This cycle does not change.

2. Ten times in each second the solenoid ground circuit is completed by the computer. This activates the mixture control solenoid.

3. If voltage control is exactly 1/2 of the time interval for each cycle, then the solenoid will be on for 1/2 of each cycle.

4. After 10 cycles on and off (or one second), the solenoid fuel jet would have been closed or the solenoid air bleed open for 1/2 or 50% of a second.

5. The percent of time during which the solenoid is "on" is called "duty cycle."

6. Duty refers to how much work time or "duty" the solenoid accomplishes. When control voltage is applied for only 1/2 of the time in each second, the duty cycle is 50%.

7. The total amount of fuel delivered by the main metering primary circuit depends on the duty cycle of the mixture-control solenoid. If the solenoid control voltage is applied and the fuel jet is closed, or the air bleed open, for only 10% of each second, fuel flow will be large in volume. This would be a 10% duty cycle.

8. If the solenoid control voltage is applied and the jet is closed, or the air bleed open, for 90% of each second, fuel flow would be small in volume. This would be a 90% duty cycle.

9. Since main jet fuel flow is limited to jet size, overall air/fuel ratio in the main metering primary circuit is varied by controlling the duty cycle of the mixture control solenoid.

    a. A low (10% or below) duty cycle (high-voltage at the solenoid ground side) delivers the richest mixture.

    b. A high (90% or above) duty cycle (low voltage at the solenoid ground side) delivers the leanest mixture.

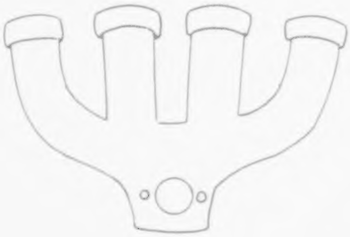
IV. Manifold design and function

A. The job of the intake manifold is to provide a connecting path between the carburetor (or throttle body on fuel-injected vehicles) and the intake ports of the cylinder head(s).

B. Intake manifold design varies significantly because of variations in engine design such as in-line 4 cyl., in-line 6 cyl., V6, V8, etc.

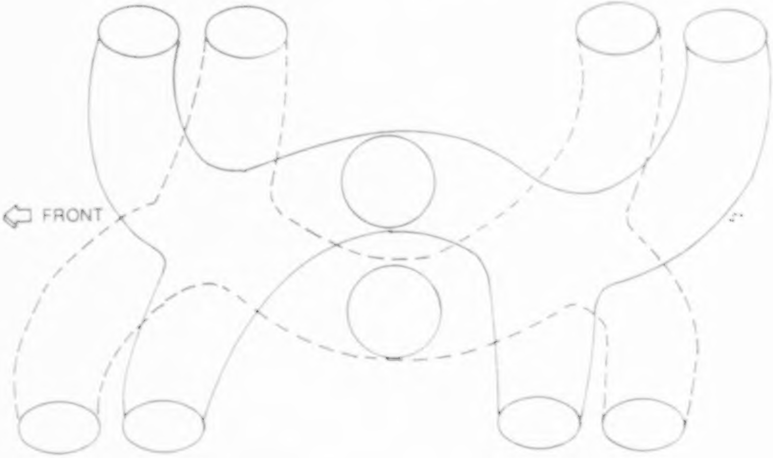
1. The ideal intake manifold would have equal length runners (paths) to each cylinder from the carburetor. The more alike in length the runners are, the more consistent will be the fuel distribution to each cylinder.

2. In an in-line engine, the intake manifold runners to the outer cylinders are much longer than the runners to the center cylinders. The in-line design results in a richer fuel mixture being delivered to the center cylinders than to the outer cylinders.



3. Engines equipped with port fuel injection have better fuel distribution because the fuel is injected at the end of the intake runner, near the intake valve.

4. V-type engine designs commonly use a dual plane intake manifold. In the V-type designs, half the cylinders are fed by one side of the carburetor and half by the other. The manifold is designed to make the runners more equal in length, allowing a more equal mixture to reach each cylinder.



C. Uses of intake manifold heat

1. Intake manifolds are commonly designed with an exhaust heat passage traveling under the base of the carburetor. The purpose of this passage is to warm the base of the carburetor (throttle body). Warming the intake aids in fuel vaporization. The fuel must vaporize for proper combustion.

2. Intake manifold exhaust heat is also used to heat the choke thermostat on many engines.

3. The exhaust traveling through the intake manifold is also used for the exhaust gas recirculation (EGR) system on many vehicles. (EGR is an emission control system that will be discussed in a later unit.)

D. The intake manifold may also have coolant passages built into the manifold. The passages may have no other purpose than to connect coolant between two cylinder heads. Other designs use the hot coolant to heat the choke thermostat and to warm the base of the carburetor for better fuel vaporization.

E. The intake manifold may also serve as the cover for the lifter valve on some V-type engines.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

CARBURETOR DESIGNS AND CONTROLS

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. What device is used to slow throttle closing?

2. What does the hot idle compensator do to the fuel mixture when the engine overheats?

3. What device controls the air/fuel mixture through the ECM?

4. What does the term duty cycle refer to in relation to the mixture control solenoid?

5. What type of intake manifold does a V-type engine use?

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

CARBURETOR DESIGNS AND CONTROLS

(ANSWER SHEET)

1. Dashpot
2. Makes the fuel mixture leaner.
3. Mixture control solenoid
4. The length of time the mixture control solenoid is energized
5. A dual plane intake manifold

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT II: CARBURETION

UNIT II TEST

SECTION A. **Match the terms below with their appropriate definitions.**

____ 1. Term that describes when a liquid turns into a gas.

____ 2. Term that describes fuel being broken into small particles.

____ 3. The upper part of a carburetor.

____ 4. The term used to describe an engine that runs after the ignition is off.

____ 5. The lowering of air pressure as air speed increases.

____ 6. The amount of time the mixture control solenoid is energized.

____ 7. An air/fuel mixture that has a low amount of fuel.

____ 8. An air/fuel mixture that has a high amount of fuel.

a. Air horn
b. Atomize
c. Dieseling
d. Duty cycle
e. Lean
f. Rich
g. Venturi effect
h. Vaporize
i. Float bowl

SECTION B. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 9. There are five basic carburetor circuits.

____ 10. Plastic float bowls are not uncommon.

____ 11. The needle and seat assembly are usually made from copper.

____ 12. The level of fuel in the float bowl is regulated by the needle and seat.

____ 13. The venturi is a restriction in the carburetor.

____ 14. During closed throttle operation, the idle circuit controls fuel flow.

____ 15. The idle restrictor limits idle speed settings.

____ 16. Metering rods can control the flow of fuel through main jets.

____ 17. The accelerator pump is connected to the throttle linkage.

____ 18. The choke creates a lean fuel mixture.

____ 19. The vacuum brake stops the choke from closing.

____ 20. A four-barrel carburetor has two primary and two secondary barrels.

____ 21. The idle control solenoid determines the idle air/fuel mixture.

____ 22. The hot idle compensator reduces the chance of flooding.

____ 23. The electronic speed control gets its voltage signal from various sensors.

____ 24. The O_2 solenoid and the O_2 sensor are two names for the same component.

SECTION C. Select the best answer from the five choices listed.

____ 25. The carburetor circuit that maintains the correct fuel level is the

a. idle circuit.
b. float circuit.
c. main metering circuit.
d. power enrichment circuit.
e. choke circuit.

____ 26. The venturi is used in

a. the acceleration circuit.
b. the choke circuit.
c. the idle circuit.
d. the main metering circuit.
e. all of the above.

____ 27. The power valve is used with

a. the acceleration circuit.
b. the choke circuit.
c. the idle circuit.
d. the main metering circuit.
e. none of the above.

____ 28. The vacuum compensator is used with

a. the acceleration circuit.
b. the choke circuit.
c. the idle circuit.
d. the main metering circuit.
e. none of the above.

____ 29. An altitude compensator

a. adds more fuel to the air.
b. adds more air to the fuel.
c. enlarges the venturi.
d. compacts the venturi.
e. does none of the above.

____ 30. In order for a three-way catalytic converter to operate effectively, the air/fuel ratio must be very close to

a. 8.7 to 1.
b. 11.7 to 1.
c. 14.7 to 1.
d. 17.7 to 1.
e. 20.1 to 1.

____ 31. The mixture control solenoid is energized by

a. the O_2 sensor.
b. the throttle position sensor.
c. the electric control module ECM.
d. the electronic control module ECM.
e. none of the above.

____ 32. An exhaust passage traveling under the carburetor is used to

a. warm the base of the carburetor.
b. aid vaporization of the fuel.
c. heat the choke thermostat.
d. aid EGR operation.
e. do all the above.

SECTION D. **Read each of the below statements made by Technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.**

____ 33. TECHNICIAN I says that float level is of little importance in carburetor operation.

TECHNICIAN II says that float bowls are generally made of cast iron.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 34. TECHNICIAN I says that today's carburetors are vented to a charcoal canister.

TECHNICIAN II says that the idle system provides air/fuel mixtures for most normal driving conditions.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 35. TECHNICIAN I says that atmospheric pressure pushes fuel through the main jet.

TECHNICIAN II says that the air bleeds prevent vapor lock.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 36. TECHNICIAN I says that fuel must first be vaporized before it can be atomized.

TECHNICIAN II says that the idle discharge ports are located below the throttle valve.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 37. TECHNICIAN I says that the power enrichment circuit is linked to the throttle linkage.

TECHNICIAN II says that the greatest fuel flow is achieved when the metering rods are forced into the jets.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 38. TECHNICIAN I says that the power enrichment system comes on at low vacuum.

TECHNICIAN II says that high vacuum is used to open the power valve.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 39. TECHNICIAN I says that a sticking choke will lower gas mileage.

TECHNICIAN II says that, as the choke is applied, a fast idle cam speeds engine rpm.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 40. TECHNICIAN I says that, as the engine starts, the choke pulloff causes the choke to open.

TECHNICIAN II says that, as the engine starts, the choke unloader causes the choke to open.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 41. TECHNICIAN I says that most modern automobiles heat the choke housing with hot coolant.

TECHNICIAN II says that two-stage, two-barrel carburetors have only one idle mixture screw.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 42. TECHNICIAN I says that variable venturi carburetors have one jet per barrel.

TECHNICIAN II says that a dashpot prevents stalling during deceleration.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 43. TECHNICIAN I says that an idle control solenoid is used to prevent run-on.

TECHNICIAN II says that an idle control solenoid is used to open the throttle a little further when the air conditioning is turned on.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 44. TECHNICIAN I says that a hot idle compensator opens a fuel return passage to lean the fuel mixture when the engine is hot.

TECHNICIAN II says that electronic idle speed control systems employ a re-usable electric motor to control idle speed.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 45. TECHNICIAN I says that, in feedback carburetors, the mixture control solenoid pulsates up to 60 times per second.

TECHNICIAN II says that, when all the sensors are working together with the ECM to control the fuel mixture, the system is said to be in open loop.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

(NOTE: The student must obtain a minimum score of _____ on the Unit II Test in order to receive an evaluation for Competencies K1-K4.)

ANSWERS TO UNIT II TEST

1.	h
2.	b
3.	a
4.	c
5.	g
6.	d
7.	e
8.	f
9.	f
10.	t
11.	f
12.	f
13.	t
14.	t
15.	f
16.	t
17.	t
18.	f
19.	f
20.	f
21.	f
22.	t
23.	f
24.	f
25.	b
26.	d
27.	e
28.	e
29.	b
30.	c
31.	d
32.	e
33.	e
34.	a
35.	a
36.	b
37.	d
38.	a
39.	c
40.	a
41.	b
42.	c
43.	c
44.	b
45.	d

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT III: CARBURETOR SERVICE

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose, adjust, and repair carburetor problems. The student will demonstrate mastery of the material by achieving a score of ______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Conduct a preliminary inspection and diagnosis of the carburetor (Competency K1, Part I of the Unit III Test).

II. Identify the procedure for carburetor removal (Competency K4, Part III of the Unit III Test).

III. Identify the procedure for carburetor disassembly (Competencies K3 and K7, Parts II and III of the Unit III Test).

IV. Identify the procedure for inspecting and cleaning the choke (Competencies K3, K4, and K7, Parts II and III of the Unit III Test).

V. Identify the procedure for carburetor assembly and adjustment (Competency K4, Part III of the Unit III Test).

VI. Demonstrate the ability to:

   a. Inspect fuel systems and diagnose fuel system problems (Competency K1, JS1-L1-UIII).

   b. Remove and disassemble the carburetor (Competencies K3, K4, and K7, JS2-L1-UIII).

   c. Assemble, adjust, and install carburetors (Competencies K3, K4, and K7, JS3-L1-UIII).

Lesson 2.

I. Identify the procedure for carburetor installation (Competency K4, Part III of the Unit III Test).

II. Identify the procedure for carburetor adjustment (Competencies K4 and K7, Part III of the Unit III Test).

III. Identify the procedure for inspecting, removing, and replacing the intake manifold (Competencies K4 and K7, Part III of the Unit III Test).

IV. Demonstrate the ability to:

   a. Adjust carburetor idle speeds (Competency K4, JS1-L2-UIII).

b. Adjust carburetor mixture by using propane enrichment method (Competencies K4 and K6, JS2-L2-UIII).

c. Remove and install an intake manifold (Competencies K4 and K6, JS3-L2-UIII).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks H028, H032-H034, and H036-H045.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT III: CARBURETOR SERVICE

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   c. Job sheets

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      JS2-L1-UIII: Removing and Disassembling the Carburetor
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2. Lesson 2: CARBURETOR INSTALLATION AND ON-CAR ADJUSTMENTS

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   b. Assignment sheet

      AS1-L2-UIII: Procedure for Adjusting Idle Speed for Noncomputer-Controlled Engine
      AS2-L2-UIII: Procedure for Propane Enrichment Idle Mixture Adjustment
      AS3-L2-UIII: Procedure for Intake Manifold Removal and Installation

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      JS1-L2-UIII: Adjusting Idle Speed for Noncomputer-Controlled Engine
      JS2-L2-UIII: Adjusting Propane Enrichment Idle Mixture
      JS3-L2-UIII: Removing and Installing the Intake Manifold

E. Unit test

F. Answers to unit test

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NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L1-UIII in conjunction with JS2-L1-UIII; AS2-L1-UIII in conjunction with JS3-L1-UIII; AS1-L2-UIII in conjunction with JS1-L2-UIII; AS2-L2-UIII in conjunction with JS2-L2-UIII; and AS3-L2-UIII in conjunction with JS3-L2-UIII.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT III: CARBURETOR SERVICE

LESSON 1: CARBURETOR REMOVAL AND BENCH REPAIR

I. Procedure for conducting a preliminary inspection and diagnosis of the carburetor

  A. Remove air cleaner and inspect filter element according to the below procedure.

    1. Remove the wing nut that holds air cleaner cover and then remove the cover.

       (NOTE: Some air filters use wire clips instead of a wing nut.)

    2. Remove air filter element for inspection. Dirty, clogged filters should be replaced.

    3. Inspect air cleaner inlet duct work. If parts are missing from the inlet duct or if the duct shows any signs of damage, the duct should be replaced.

  B. Inspect choke operation (cold engine) according to the below procedure.

    1. When engine is cold, choke should close when throttle is opened. If choke does not close, check for binding linkage.

    2. Open throttle and move choke by hand. Choke operation should be smooth with no binding.

    3. Clean any dirt and gum deposits on the choke linkage. The deposits may be cleaned by using a spray carburetor solvent and compressed air.

    4. Check operation of choke unloader.

       a. Open the throttle all the way while choke is closed.

       b. Choke should open about 1/4 inch. (The precise amount that the choke will open varies with choke design and application.)

       c. If unloader does not open choke, check linkage adjustment.

    5. Check operation of choke pulloff according to the procedure outlined below.

       a. Remove vacuum hose from choke pulloff diaphragm.

       b. Using an external vacuum source (a hand-operated vacuum pump works nicely), apply vacuum to the pulloff.

       c. Choke should open slightly (the amount varies with application).

  C. Check the operation of the accelerator pump, according to the below procedure.

    1. With the choke held open, slowly and steadily open the throttle while observing discharge from accelerator pump discharge nozzle(s).

    2. A steady stream of fuel should discharge from each nozzle.

D. Visually inspect inlet lines, bowl gaskets, etc. for external fuel leaks.

(**CAUTION:** Fuel leaks are a fire hazard and must be corrected.)

E. According to the below procedure, check the operation of the choke while the engine is running.

1. Plug any vacuum hoses disconnected when removing the air cleaner. Start the engine and bring it to operating temperature.

2. Observe operation of the choke.

   (NOTE: The engine must be cold at the beginning of this procedure.)

   a. Choke should slowly open as engine warms up.

   b. When it is cold, the engine should operate on fast idle and, therefore, should not stall.

   c. Observe tail pipe for black smoke. Black smoke may be an indication that the choke is sticking or that the choke is set for a fuel mixture that is "too rich."

3. After engine reaches operating temperature, the choke should be fully open and the engine should be running at curb idle speed. Depending on design, it may be necessary to tap the accelerator to bring the carburetor down from fast idle speed to curb idle.

4. Check for carburetor flooding.

   a. While engine is idling, look into the throat of the carburetor.

   b. Check for fuel discharge at the high-speed discharge nozzle(s).

   c. Any fuel discharge from the nozzle(s) is an indication of a leaking float needle/seat.

   d. Shut engine off.

F. Adjust the accelerator linkage according to the below procedure.

a. With the engine off, have a helper depress the accelerator pedal to the floor.

b. Using a flashlight, look into the carburetor. The throttle should be wide open.

(NOTE: The secondary of staged two-barrel and four-barrel carburetors may or may not open. If secondaries are operated mechanically, they should be open. If secondaries are vacuum operated, they will not be open.)

II. Procedure for removing a carburetor

A. Disconnect the negative cable of battery to prevent engine from being cranked while carburetor is removed.

B. Remove air cleaner and gasket.

C. Disconnect wire at idle solenoid and mixture-control solenoid if so equipped.

D. Place a towel under the fuel inlet and disconnect fuel inlet line.

E. Disconnect vacuum lines and mark the location with masking tape for reassembly.

F. Disconnect choke rod.

G. Disconnect accelerator linkage.

H. Disconnect transmission downshift/throttle cable (if so equipped).

I. Disconnect speed control linkage (if so equipped).

J. Remove carburetor mounting bolts and carburetor.

K. While carburetor is removed, place a clean towel over holes in the intake manifold to prevent foreign objects from falling into the manifold.

III. Disassembling a carburetor

A. Work in a clean, well-lighted area. Place carburetor in a suitable holding fixture. Failure to do so can result in bent or damaged throttle valves (plates).

B. Drain gas from carburetor into a suitable container for proper disposal.

C. Use a small-parts basket to hold all screws, clips, and other such items removed from the carburetor.

(NOTE: Due to the wide variances in carburetor design and service procedures, the following instructions are very general in nature. Refer to the appropriate service manual when servicing a specific carburetor.)

D. If equipped with an in-carburetor fuel filter, remove and discard the filter.

E. Remove the mixture-control solenoid.

F. Remove the idle-control solenoid or dashpot.

G. Remove the choke thermostat (if mounted on carburetor body).

    1. To show the choke adjustment before disassembly, scribe a mark on the choke housing.

    2. In many late-model vehicles, the choke cover is held in place with rivets. To remove cover, drill out rivets with a suitable drill.

    (NOTE: The choke thermostat should not be removed from the cover.)

H. Remove choke pulloff.

I. Remove carburetor air horn (bowl cover).

    1. Remove all clips and rods attached to choke shaft and accelerator pump.

    2. Disassemble and remove bowl vent valve.

    3. Remove all screws from air horn and remove air horn and gasket.

J. Remove float assembly.

    1. Remove float and store it in a safe place.

    2. Remove float needle valve and seat.

K. Remove accelerator pump and check balls. Note position of check balls.

L. Remove power valve.

M. Remove main metering jets.

N. Remove screws attaching throttle body to bowl and separate the two pieces.

(NOTE: Do not remove the screws holding the throttle plates and choke plate in position. These screws are factory-installed and staked in position and, therefore, are normally not removed for service.)

O. Remove the idle-mixture screws.

1. On most late-model vehicles, the concealment plugs will have to be removed in order to gain access to the idle-mixture screws.

2. Using a hacksaw blade, make two parallel cuts in the throttle body on either side of the locator points beneath the idle mixture needle plug.

   a. The cuts should reach down to the steel plug but should not extend more than 1/8 of an inch beyond the locator points.

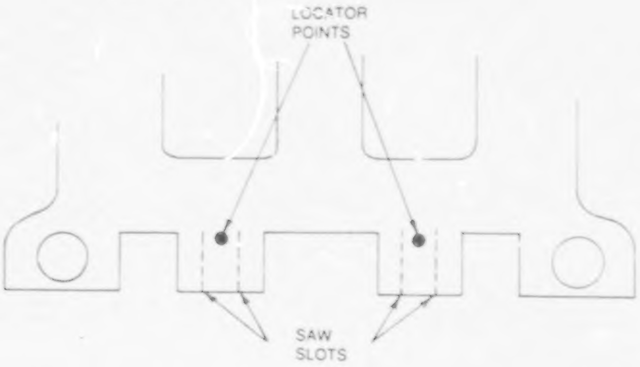
   b. The distance between the saw marks depends on the size of the punch to be used.

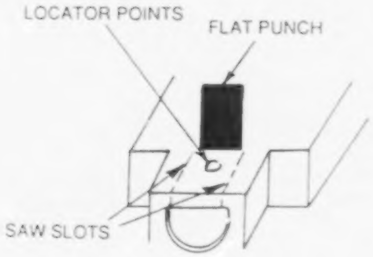
3. Place a flat punch at a point near the ends of the saw marks in the throttle body.

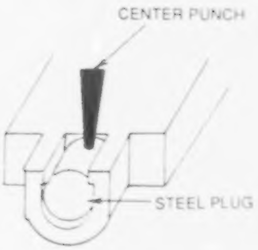
   a. Holding the punch at a 45-degree angle, drive it into the throttle body until the casting breaks away, exposing the steel plug.

   b. Holding a center punch vertically, drive it into the steel plug. Then holding the punch at a 45-degree angle, drive the plug out of the casting. The mixture screw can then be removed.

   (NOTE: The hardened steel plug will break. Simply remove the broken pieces.)







IV. Inspecting and cleaning the choke

A. Procedure for inspecting the choke

1. Inspect choke shaft for excessive looseness in air horn. If excessive looseness is present, air horn should be replaced.

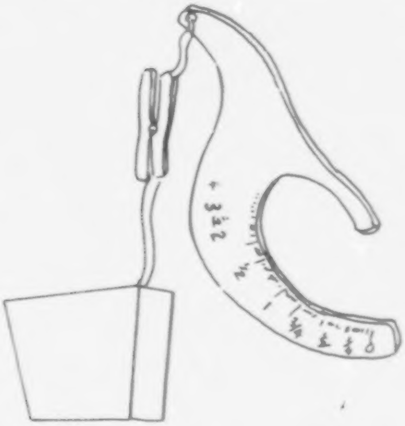
2. Inspect throttle shaft in the same manner. If it is excessively loose, the throttle body mst be replaced.

3. Carefully examine float.

    a. Shake hollow floats and listen for sloshing of gasoline. If gas is detected, the float must be replaced.

    b. Solid nitrile floats may be weighed to check for gasoline contamination.

    c. Nitrile floats sometimes absorb gasoline, become heavy, and sink. Weighing the float can determine whether it is suitable for use.



4. Inspect all castings for cracking or other damage.

B. Procedure for cleaning the choke

1. Remove all gaskets, o-rings, etc. from all parts.

2. Clean carburetor in an immersion-type carburetor cleaner.

    a. Place all small parts in a small-parts basket.

    b. Place the small-parts basket and all large parts in a large-parts basket. Next, place the basket in a cleaning solution. Clean carburetor according to the solvent manufacturer's instructions.

       (**CAUTION:** Immersion-type carburetor cleaner will burn skin and eyes. Wear eye protection and do not allow cleaner to come in contact with skin.)

c. Parts containing rubber, plastic, or electrical wiring should not be immersed. The following is a list of some of the items that should not be placed in cleaning solution.

-idle solenoid
-choke cover
-mixture-control solenoid
-plastic floats
-choke pulloff
-plastic fuel bowl
-other parts as identified by manufacturer

3. After removing the basket from the cleaner, rinse all parts in hot water and blow them dry with compressed air.

V. Assembling and adjusting the carburetor

A. Procedure for assembling the carburetor

1. Assemble carburetor in reverse order of disassembly.

2. Tighten all fasteners to the torque specified in the appropriate service manual.

3. Make all necessary adjustments during assembly.

4. Some adjustments are dependent on other adjustments. Be sure to make all adjustments according to the service manual and in the order they are given.

5. Replace all gaskets, o-rings, etc. with new ones. The technician can use a carburetor repair kit that includes all parts normally needed to reassemble the carburetor.

6. Identification numbers are either stamped on the carburetor or on an attached tag. These numbers make it easier for the technician to identify parts and to determine proper adjustment specifications. If the carburetor identification numbers cannot be found, refer to the appropriate service manual for their location.

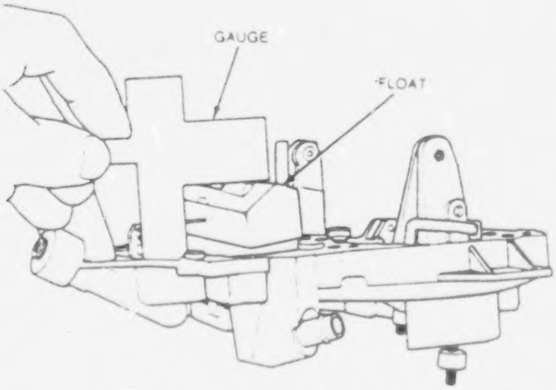
B. Procedure for adjusting the carburetor during assembly

1. After installing the float, measure the float level and adjust it as necessary.

a. Depending on the manufacturer's design, adjustment may be made by bending the float arm, turning an adjustment screw, or using selective shims between carburetor body and inlet seat.

b. When adjusting a float by bending the arm, bend only where instructed by the manufacturer.

c. Measurement normally is made by using a drill rod or ruler.



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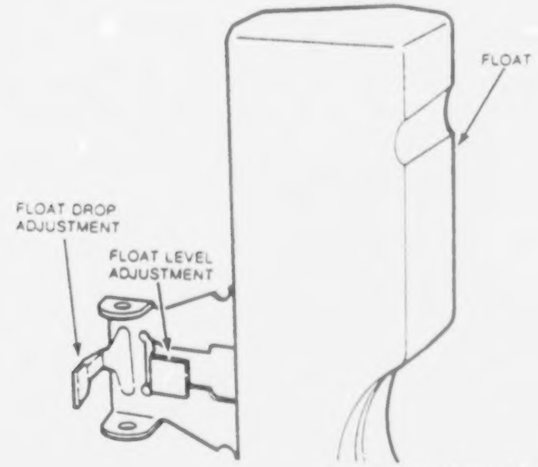
2. Adjust float drop. This adjustment is usually made by bending a tang on the float arm.



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3. Adjust the fast-idle cam position. The proper positioning of the fast idle cam when the choke is closed is important to cold engine operation. Adjustment is usually made through the bending of the cam linkage.

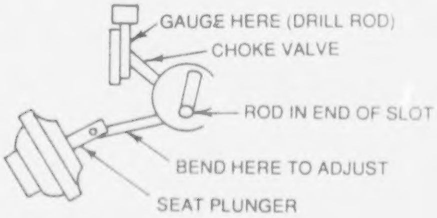
   (NOTE: Follow instructions carefully when performing fast-idle cam adjustments as well as all other adjustments.)

4. Adjust choke pulloff.

   a. Choke pulloff adjustment is normally made through the bending of a linkage or the turning of an adjustment screw.

   b. It is usually necessary to apply an external vacuum source to the pulloff diaphragm during this adjustment.

c. Measurement for choke pulloff adjustment and other choke adjustments is made by using a drill rod or, in some cases, a degree scale, which is attached to the choke valve.

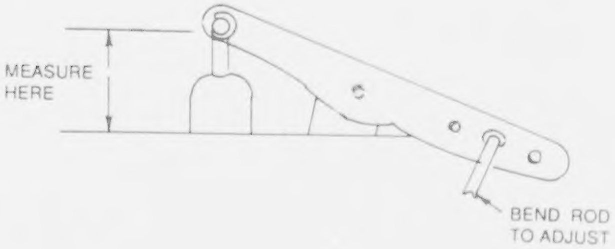


5. Adjust choke unloader. The choke unloader is usually adjusted by bending a choke linkage. Measurement is normally made by using a drill rod.

   (NOTE: The choke unloader adjustment is important because it gives the operator the ability to deflood a cold engine by depressing the accelerator to the floor, thus forcing the choke open a predetermined amount.)

6. Adjust the accelerator pump. The accelerator pump is normally adjusted by bending a linkage. In some carburetors, however, the pump is adjusted by turning an adjusting screw.

   (NOTE: Proper accelerator pump adjustment ensures that the proper amount of fuel is discharged when the accelerator is depressed. This prevents engine stumbling and hesitation.)



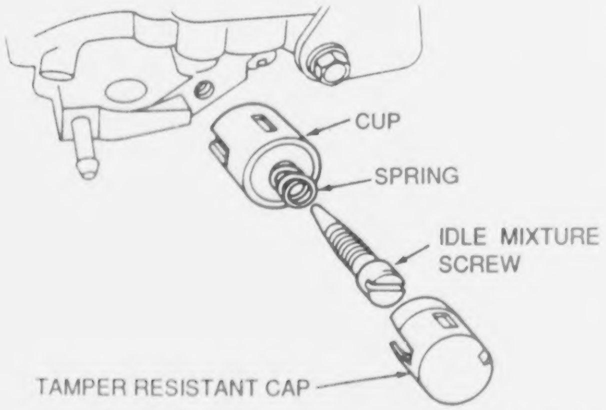
7. Make preliminary adjustment of the mixture screw.

   (NOTE: Final mixture screw adjustment cannot be done until the carburetor is reassembled, installed on the car, and the engine is running.)

   a. A normal starting point adjustment is to turn the mixture screw in until it is lightly seated, then back out 1 and 1/2 to 2 turns.

   b. This setting should allow the engine to start and idle well enough until final adjustments can be made.

c. Do not reinstall concealment plugs until after on-car adjustments are complete.


CUP
SPRING
IDLE MIXTURE SCREW
TAMPER RESISTANT CAP

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MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR CARBURETOR REMOVAL AND DISASSEMBLY

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, engine size, and year of the vehicle to be serviced.
2. Develop a logically written procedure for removing the carburetor from the vehicle.
3. Develop a logically written procedure for disassembling the carburetor.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR CARBURETOR ASSEMBLY, BENCH ADJUSTMENTS AND INSTALLATION

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, engine size, and year of the vehicle to be serviced.
2. Determine and record the carburetor identification number from the vehicle to be serviced.
3. Develop a logically written procedure for carburetor assembly and bench adjustments. Be sure to include all necessary specifications.
4. Develop a logically written procedure for carburetor installation. Be sure to include all necessary specifications.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

INSPECTING AND DIAGNOSING THE FUEL SYSTEM

Equipment:

Hand tools
Hand vacuum pump
Serviceable vehicle
Safety glasses

Procedure: Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

   (NOTE: The test should begin with a cold engine. A cold engine is one that has not been run for 8 hours or more.)

2. Inspect air filter, filter housing, and ducts. ___ ___ ___ ___

   OK_____ NOT OK_____

3. Inspect the choke and answer the below questions. ___ ___ ___ ___

   a. Does choke close as it should?

      YES_____ NO_____

   b. Does the choke operate smoothly by hand?

      YES_____ NO_____

   c. Does the choke unloader work?

      YES_____ NO_____

4. Test the choke pull-off operation. ___ ___ ___ ___

   OK_____ NOT OK_____

5. Test accelerator pump operation. ___ ___ ___ ___

   OK_____ NOT OK_____

6. Inspect for external fuel leakage. ___ ___ ___ ___

   OK_____ NOT OK_____

7. Connect exhaust ventilation equipment, start the engine, and bring it to operating temperature. — — — —

   (**CAUTION:** Be sure to use approved exhaust ventilation equipment when operating a vehicle in an enclosed area.)

8. Does the choke open as it should? — — — —

   YES____ NO____

9. Check the carburetor for flooding. — — — —

   OK____ NOT OK____

10. Shut engine off and disconnect exhaust ventilation equipment. — — — —

11. Check accelerator linkage for adjustment and smoothness of operation. — — — —

    OK____ NOT OK____

12. In the space below, record any of the problems encountered during the above testing. Also indicate what the causes of the problem might be. — — — —

*Average of above evaluations — — — —

(*This average is a partial evaluation for Competency K1. Final evaluation for K1 will be made at the end of JS2-L3-UVI.)

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

REMOVING AND DISASSEMBLING THE CARBURETOR

Equipment:

Hand tools
Serviceable vehicle
Special tools as outlined in assignment sheet
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Complete AS1-L1-UIII. Following the procedure developed in item 2 of AS1-L1-UIII, remove the carburetor from the vehicle. ___ ___ ___ ___

   (NOTE: Before beginning the carburetor removal procedure, disconnect the negative battery cable to prevent inadvertent cranking of the engine. Also place a towel over the intake after carburetor is removed to prevent foreign objects from falling into the engine.)

   (CAUTION: Automotive fuel is highly flammable. Do not service fuel systems in the presence of sparks or open flame. Store fuel in approved sealed containers. Clean up any fuel spill immediately.)

3. Following the procedure developed in item 3 of AS1-L1-UIII, disassemble the carburetor. ___ ___ ___ ___

4. Inspect the carburetor components according to the outline below and answer the following questions. ___ ___ ___ ___

   a. Inspect the float.

      OK_____ NOT OK_____

   b. Inspect the choke shaft and choke valve for wear or binding.

      OK_____ NOT OK_____

   c. Inspect the throttle shaft and plates for wear or binding.

      OK_____ NOT OK_____

   d. Inspect for signs of dirt or water contamination.

      OK_____ NOT OK_____

      (NOTE: If evidence of contamination is found, the fuel tank and lines should be drained and flushed with clean fuel before installing the carburetor.)

e. Inspect for signs of cracking or other damage to the carburetor.

OK____ NOT OK____

5. Separate all parts to be placed in cleaning solution. Clean carburetor components according to instruction provided by the manufacturers of the cleaner and the manufacturers of the carburetor. — — — —

(**CAUTION:** Always wear approved eye protection when working with immersion type carburetor cleaner. Do not allow immersion type carburetor cleaner to contact skin and eyes.)

6. Remove all parts from cleaner, rinse in hot water and blow dry. — — — —

*Average of above evaluations — — — —

(*This average is a partial evaluation for Competencies K3, K4, and K7. Final evaluation for K3 will be made at the end of JS3-L1-UIII. Final evaluation for K4 will be made at the end of JS3-L2-UIII. Final evaluation for K7 will be made at the end of JS5-L2-UIV.)

JS3-L1-UIII

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PERFORMING BENCH ADJUSTMENTS AND INSTALLING CARBURETOR ASSEMBLY

Equipment:

Hand tools
Serviceable vehicle
Special tools as outlined in assignment sheet
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Complete AS2-L1-UIII. Following the procedure developed in item 3 of AS2-L1-UIII, reassemble the carburetor and perform bench adjustments. ___ ___ ___ ___

   (NOTE: Work should be performed in a clean and well-lighted environment.)

3. Following the procedure developed in item 4 of AS2-L1-UIII, reinstall the carburetor on the vehicle. ___ ___ ___ ___

4. Connect exhaust ventilation equipment to vehicle exhaust, start engine and bring it to operating temperature. Inspect for fuel leakage and correct immediately if found. Record observations. ___ ___ ___ ___

   (**CAUTION**: Be sure to use approved exhaust ventilation equipment when operating vehicle in an enclosed area.)

5. Adjust idle mixture and speed as outlined in JS2-L2-UIII. — — — —

*Average of above evaluations — — — —

(*This average is a partial evaluation for Competencies K3, K4, and K7. Final evaluation for K3 will be made below. Final evaluation for K4 will be made at the end of JS3-L2-UIII. Final evaluation for K7 will be made at the end of JS5-L2-UIV.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency K3 by averaging the evaluations of JS2-L1-UIII and JS3-L1-UIII. Use the spaces provided below.

	Evaluation 3 2 1 N
JS2-L1-UIII	— — — —
JS3-L1-UIII	— — — —
Final evaluation for Competency K3	— — — —

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT III: CARBURETOR SERVICE

LESSON 2: CARBURETOR INSTALLATION AND ON-CAR ADJUSTMENTS

I. Procedure for installing the carburetor

   A. After all bench repairs and adjustments are complete, the carburetor should be installed in reverse order of removal.

   B. Always replace the fuel filter when installing a reconditioned or new carburetor.

   C. Tighten carburetor mounting bolts to the specified torque.

   D. Operate throttle while checking for signs of binding or sticking.

   E. Start engine and check for fuel leaks. Make all necessary adjustments.

II. Adjusting the carburetor

   (NOTE: As with other carburetor service procedures, the following adjustments vary greatly depending on the year, make, model, and engine size of the vehicle to be serviced. The below procedures are general in nature and will not apply to a specific vehicle.)

   (NOTE: Always check and correct ignition timing before attempting any carburetor adjustments. Engine timing is critical to the proper performance of the carburetor.)

   A. Idle mixture adjustment (no emission control)

      (NOTE: The below procedure can be used to adjust idle mixture on older vehicles, which are not subject to emission control.)

      1. Connect tachometer and adjust idle speed to specified rpm.

      2. Adjust mixture screw(s) to obtain smoothest idle.

      3. Reset idle speed to specification.

      4. Turn mixture screw in until rpm begins to drop; then slowly back the screw out until the best idle is achieved. On two- and four-barrel carburetors, repeat this procedure with the other screw.

      5. Reset the idle speed to specification.

   B. Propane enrichment idle adjustment (admission control)

      (NOTE: With the advent of emission controls, an idle mixture adjustment method that ensures the correct settings for low exhaust emissions became necessary. The generally accepted method is the propane enrichment method. In this method, propane is injected into the engine intake at idle while a tachometer is observed. If drop in rpm is less than specified, the air/fuel ratio is too rich. If gain in rpm is too great, the air/fuel ratio is too lean.)

(NOTE: The following is a description of propane enrichment procedures for one vehicle. Although specifications and procedures vary, the basic ideas in the following description can be considered typical.)

1. Disconnect and plug vacuum hose at EGR valve.
2. Ground the carburetor switch with a jumper wire.
3. Disconnect and plug the 3/16" diameter hose at the canister.
4. Remove the PCV valve from the valve cover and allow it to draw underhood air.
5. Connect a tachometer to the engine.
6. Start the engine and allow the speed to stabilize for two minutes.
7. Disable the computer so it will not control the carburetor. The carburetor can be disabled by: removing the vacuum hose from the carburetor and plugging it; unplugging the carburetor leads going to the carburetor; or unplugging the oxygen sensor. Check the appropriate service manual for the best procedure for the vehicle being serviced.

   (**CAUTION:** Always refer to the appropriate service manual when servicing a computer-controlled fuel systems.)

8. Let the engine run for 4 minutes to allow the effect of disconnecting the oxygen sensor to take place.
9. Disconnect the hose from the heated air door sensor at the carburetor and install the propane supply in its place.
10. Open the propane main valve. Slowly open the propane metering valve until maximum engine speed is reached.

    (NOTE: When too much propane is added, engine speed will decrease. Fine tune the metering valve for the highest engine rpm. Also, if idle mixture is extremely rich, engine rpm will decrease with any amount of propane. In this case, turn the idle mixture screw in about 1/2 turn and repeat step 12.)

11. With the propane still flowing, adjust idle speed screw on the solenoid until the tachometer indicates the specified propane rpm.
12. Turn off the main propane valve and allow the engine speed to stabilize.
13. Slowly adjust the mixture screw(s) until the tachometer indicates the specified idle set rpm. Pause between adjustments to allow the engine speed to stabilize.
14. Turn on the propane valve.
15. Fine tune the metering valve to get the highest engine rpm. If the maximum speed is more than 25 rpm different from the specified propane rpm, repeat steps 12 through 17. If maximum speed is acceptable, continue with test.
16. Turn off both valves on the propane bottle.
17. Reconnect oxygen sensor wire.
18. Reconnect hose to computer.
19. Reinstall PCV valve.

20. Reconnect carbon canister.

21. Remove ground wire from carburetor switch.

22. Reconnect hose to EGR.

    (NOTE: The idle speed with the engine in normal operating condition [everything connected] may vary from set speeds. Do not readjust.)

23. Turn engine off and remove tachometer.

24. Reinstall concealment plug. START HERE

C. Procedure for adjusting fast idle

(NOTE: Fast idle can normally be set to correct the fast idle speed. Specification for fast idle can be found on the under-hood decal or in an appropriate service manual. Adjustment is usually accomplished by turning the fast-idle adjusting screw after certain criteria are met. The criteria vary from model to model.)

1. Make sure engine is at operating temperature and transmission is in park.

2. Set adjusting screw on second step of fast idle cam. Turn screw clockwise to increase speed.

D. Procedure for adjusting curb idle

(NOTE: Procedure for adjusting idle speed may vary greatly, depending on the type of system. The following are examples of typical idle adjustment procedures.)

1. On some vehicles the idle speed can be adjusted with the idle stop screw. A tachometer is connected to the vehicle and the engine is brought to operating temperature. The screw is simply turned in or out to meet the specified idle speed.

2. Idle speed can also be adjusted with the idle solenoid.

   (NOTE: Depending on the purpose of the solenoid, this procedure will vary.)

   a. Start the engine and bring it to operating temperature.

   b. Disconnect wire from idle solenoid and adjust throttle stop screw to specified rpm.

   c. Reconnect solenoid and adjust solenoid to specified rpm. Follow all instructions concerning adjustment procedures and solenoid engagement.

III. Replacing, inspecting, and removing the intake manifold

(NOTE: Intake manifold removal and replacement procedures vary greatly, depending on engine design. The following is only an example. Follow the instructions outlined in the appropriate service manual when working with a specific vehicle.)

A. Procedure for removing intake manifold

1. Disconnect battery.

2. Drain coolant from the radiator and engine block.

3. Remove air cleaner.

4. Remove air conditioning mounting bracket (if equipped) and move air conditioning compressor out of the way.

5. Disconnect wire from temperature sending unit.

6. Disconnect throttle linkage at carburetor.

7. Disconnect fuel line at carburetor.

8. Disconnect all vacuum lines necessary for removal. Mark location with masking tape.

9. Disconnect all electrical connectors at carburetor.

10. Disconnect fuel line at carburetor.

11. Remove carburetor from manifold.

12. Remove intake manifold attaching bolts and remove manifold.

B. Procedure for cleaning and inspecting an intake manifold

1. Clean old gaskets and gasket surfaces on the intake and engine. Clean manifold in solvent and blow it dry with compressed air. Use care with aluminum manifolds. Aluminum manifolds can be easily gouged with a scraper.

2. Inspect manifold for cracking. Use a straightedge to inspect mating surfaces of manifold for flatness. Compare results to specifications.

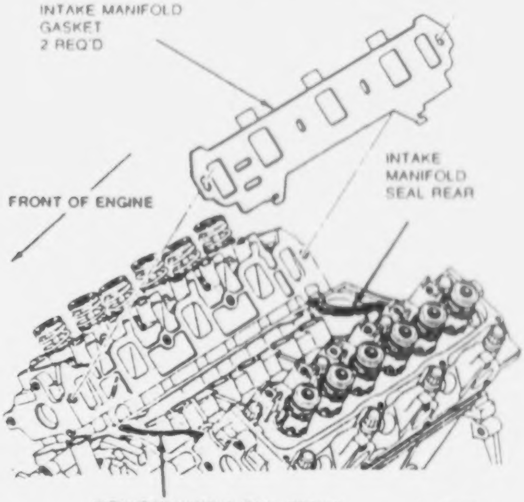
3. Inspect the exhaust crossover passages through the manifold. If passages are coated with hard black carbon, the passages should be thoroughly cleaned to remove deposits.

C. Procedure for installing an intake manifold

1. Put new intake manifold gaskets and end seals in place on the engine. (Gasket sealer may or may not be used, depending on manifold and gasket design. See instructions before applying any kind of sealer.)

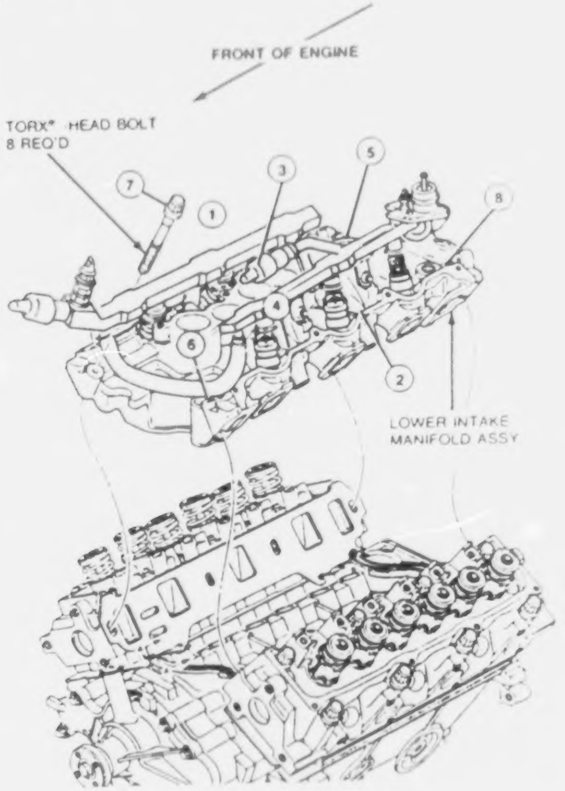
2. Apply RTV silicone sealant to the ends of the end seals. Apply the RTV silicone sealant at the point where the engine block and cylinder head meet.

   (NOTE: If the vehicle is equipped with an oxygen sensor, use only an RTV silicone sealant that is approved for use in engines with oxygen sensors. Using other types of RTV silicone sealant will damage the sensor.)


INTAKE MANIFOLD GASKET 2 REQ'D
INTAKE MANIFOLD SEAL REAR
FRONT OF ENGINE
INTAKE MANIFOLD SEAL FRONT

3. Position the intake manifold. Start the bolts that attach the manifold to the cylinder head.

4. Tighten the manifold bolts to specified torque. Follow the proper tightening sequence.


FRONT OF ENGINE
TORX® HEAD BOLT
8 REQ'D
7
1
3
5
8
4
6
2
LOWER INTAKE
MANIFOLD ASSY

5. Reinstall other parts in reverse order of disassembly.

6. Refill radiator with coolant, start the engine, and bring it to operating temperature.

7. Check system for fuel, oil, and coolant leaks.

8. Top off coolant level as needed.

9. Adjust the carburetor.

10. Adjust the timing.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR ADJUSTING IDLE SPEED FOR NONCOMPUTER-CONTROLLED ENGINE

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, engine size, and year of the vehicle to be serviced.
2. Develop a logically written procedure for adjusting all idle speeds.
3. Determine and record all idle speed specifications.
    a. Fast idle
    b. Curb idle
    c. Slow idle

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR PROPANE ENRICHMENT IDLE MIXTURE ADJUSTMENT

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, engine size, and year of the vehicle to be serviced.

2. Develop a logically written procedure for removing the idle mixture concealment plugs on the vehicle to be serviced. Be sure to include all necessary specifications.

3. Develop a logically written procedure for performing a propane enrichment procedure on the vehicle to be serviced. Be sure to include all necessary specifications.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR INTAKE MANIFOLD REMOVAL AND INSTALLATION

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, engine size, and year of the vehicle to be serviced.
2. Develop a logically written procedure for removing the intake manifold.
3. Develop a logically written procedure for cleaning and inspecting an intake manifold. Make suer to include warpage tolerances.
4. Develop a logically written procedure for installing the intake manifold. Be sure to determine the intake manifold fastener torque and tightening sequence and include it in the procedure.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

ADJUSTING IDLE SPEED FOR NONCOMPUTER-CONTROLLED ENGINE

Equipment:

Hand tools
Serviceable vehicle
Tachometer
Special tools as outlined in assignment sheet
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Complete AS1-L2-UIII. Following the procedure developed in item 2 of AS1-L2-UIII, set all applicable idle speeds (slow, curb, fast). Be sure to use the proper specifications as recorded in item 3 of AS1-L2-UIII. ___ ___ ___ ___

(**CAUTION:** Be sure to use approved exhaust ventilation equipment when operating vehicle in an enclosed area.)

*Average of above evaluations ___ ___ ___ ___

(*This average is a partial evaluation for Competency K4. Final evaluation for K4 will be made at the end of JS3-L2-UIII.)

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

ADJUSTING PROPANE ENRICHMENT IDLE MIXTURE

Equipment:

Hand tools
Propane enrichment equipment
Tachometer
Serviceable vehicle
Safety glasses

Procedure:

		Evaluation 3 2 1 N
1.	Wear safety glasses while doing all procedures on this job sheet.	___ ___ ___ ___
2.	Following the procedure developed in item 2 of AS2-L2-UIII, remove the idle mixture concealment plugs.	___ ___ ___ ___
3.	Connect exhaust ventilation equipment to vehicle exhaust, start the engine and bring it to operating temperature.	___ ___ ___ ___
	(NOTE: If the carburetor was removed in item 2 above, check for fuel leakage and correct as needed.)	
	(**CAUTION:** Be sure to use approved exhaust ventilation equipment when operating a vehicle in an enclosed area.)	
4.	Following the procedure developed in item 3 of AS2-L2-UIII, adjust the carburetor mixture using the propane enrichment method.	___ ___ ___ ___
5.	Shut engine off and disconnect equipment from vehicle.	___ ___ ___ ___
	*Average of above evaluations	___ ___ ___ ___

(*This average is a partial evaluation for Competencies K4 and K6. Final evaluation for K4 will be made at the end of JS3-L2-UIII. Final evaluation for K6 will be made at the end of JS4-L2-UV.)

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

REMOVING AND INSTALLING THE INTAKE MANIFOLD

Equipment:

Hand tools
Special tools as outlined in assignment sheet
Serviceable vehicle
Safety glasses

Procedure:

Procedure	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2. Complete AS3-L2-UIII. Following the procedure developed in item 2 of AS3-L2-UIII, remove the intake manifold.	__ __ __ __
3. Following the procedure developed in item 3 of AS3-L2-UIII, clean and inspect the intake manifold. Answer the below questions.	__ __ __ __

(NOTE: Clean old gaskets from mating surfaces on both the engine and intake. Clean carbon from exhaust crossover passage.)

a. Are there any cracks in the manifold?

YES_____ NO_____

b. Are mating surfaces within the proper tolerances?

YES_____ NO_____

c. Are there any problems with this intake manifold?

YES_____ NO_____

d. Describe any problems found during the inspection.

4. Following the procedure developed in item 4 of AS3-L2-UIII, install the intake manifold. — — — —

(NOTE: Be sure to fill engine with coolant, connect exhaust ventilation equipment, start engine and bring it to operating temperature. Inspect for and correct any coolant, gasoline or engine oil leaks.)

*Average of above evaluations — — — —

(*This average is a partial evaluation for Competencies K4 and K6. Final evaluation for K4 will be made below. Final evaluation for K6 will be made at the end of JS4-L2-UV.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency K4 by averaging the evaluations of JS2-L1-UIII, JS3-L1-UIII, JS1-L2-UIII, JS2-L2-UIII, and JS3-L2-UIII. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS2-L1-UIII	—	—	—	—
JS3-L1-UIII	—	—	—	—
JS1-L2-UIII	—	—	—	—
JS2-L2-UIII	—	—	—	—
JS3-L2-UIII	—	—	—	—
Final evaluation for Competency K4	—	—	—	—

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT III: CARBURETOR SERVICE

UNIT III TEST

PART I. DIAGNOSING FUEL SYSTEM PROBLEMS

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 1. A good accelerator pump will provide a steady stream of fuel to the carburetor as the throttle is opened.

____ 2. Blue smoke from the exhaust is an indication that the choke is set for a fuel mixture that is too rich.

____ 3. The choke should cause the engine to fast idle when the engine is cold.

____ 4. If the accelerator pump is misadjusted, the engine will not idle properly on cold mornings.

____ 5. Dirt and gum deposits should be removed from the choke plate with gasoline and compressed air.

SECTION B. **Read each of the below statements made by Technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.**

____ 6. TECHNICIAN I says that any defective duct work running to the air cleaner should be repaired or replaced.

TECHNICIAN II says that, when the engine is cold, the choke should close as the throttle is opened.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 7. TECHNICIAN I says that, if the choke unloader does not open the choke when the engine is cold, the unloader is working properly.

TECHNICIAN II says that, when vacuum is applied to the choke unloader, the choke should open slightly.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 8. TECHNICIAN I says that during the idle, no fuel should be discharged from the main discharge nozzle.

TECHNICIAN II says that on stages two or four barrel carburetors the secondaries should be open when the throttle is completely open.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

(NOTE: The student must obtain a minimum score of _____ on Part I of the Unit III Test in order to receive an evaluation for Competency K1.)

PART II. DISASSEMBLING, CLEANING, AND INSPECTING CARBURETORS

SECTION A. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 9. Parts containing rubber, plastic, or electric wiring should not be cleaned with the same solvent that is used to clean metal carburetor parts.

____ 10. Carburetor parts should be rinsed with hot water to remove cleaning solvent.

____ 11. The throttle and choke plates are usually removed when the carburetor is rebuilt.

____ 12. Late-model vehicles will require the removal of concealment plugs to gain access to idle speed screws.

____ 13. During inspection, the casting of the carburetor should be checked for cracks.

____ 14. The choke housing should be scribed before disassembly.

____ 15. Float drop is usually made by bending a tang on the float arm.

____ 16. The adjustment of the fast idle cam is usually accomplished by turning a screw.

____ 17. Always replace the fuel filter when installing a reconditioned or new carburetor.

____ 16. Always place a clean towel over the holes in the intake manifold to prevent foreign objects from falling into the engine.

SECTION B. Select the best answer from the five choices listed.

____ 17. When disassembling a carburetor before rebuilding it, the technician should

a. work in a clean, well-lighted area.
b. place the carburetor on a stand to protect the throttle valves.
c. drain the fuel from the carburetor.
d. place small carburetor parts in a basket.
e. do all of the above.

____ 18. Idle mixture screw preliminary adjustment is usually

a. 1 to 1 1/2 turns out.
b. 1 1/2 to 2 turns out.
c. 1 to 1 1/2 turns in.
d. 1 1/2 to 2 turns in.
e. none of the above.

____ 19. When cleaning the carburetor during rebuilding, the technician should use

a. spray carburetor cleaner.
b. parts cleaning solvent.
c. fuel system cleaning solvent.
d. soap and water.
e. none of the above.

SECTION C. **Read each of the below statements made by Technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.**

____ 20. TECHNICIAN I says that choke covers on late-model vehicles are not removed during carburetor rebuilding.

TECHNICIAN II says that, when the float assembly is removed, the position of the check balls should be noted.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 21. TECHNICIAN I says that concealment plugs are removed by chiseling them from the carburetor.

TECHNICIAN II says that the throttle and choke shafts should be checked for excessive looseness during carburetor rebuilding.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 22. TECHNICIAN I says that it is usually unnecessary to have an external vacuum source when adjusting the choke pulloff.

TECHNICIAN II says that the choke unloader allows for the deflooding of a cold engine.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 23. TECHNICIAN I says that identification numbers are very important for determining proper adjustment specifications.

TECHNICIAN II says that most floats are adjusted by adjusting the length of the needle.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 24. TECHNICIAN I says that floats can be checked by shaking them and listening for a sloshing sound.

TECHNICIAN II says that floats can be checked by weighing them.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 25. TECHNICIAN I says that, before carburetor removal, the negative cable of the battery should be removed to prevent the engine from being cranked.

TECHNICIAN II says that the location of vacuum lines should be marked to aid in reassembly.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

(NOTE: The student must obtain a minimum score of _____ on Part II of the Unit III Test in order to receive an evaluation for Competency K3.)

PART III. REASSEMBLING AND ADJUSTING CARBURETORS

SECTION A. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 26. Propane enrichment cannot be used to adjust carburetors on computer-controlled fuel systems.

____ 27. Fast idle adjustment is done when the engine is cold and the choke is on.

____ 28. The idle solenoid is adjusted in different ways, depending on the purpose of the solenoid.

____ 29. When too much propane is added to an engine, the idle speed will soar.

____ 30. Curb idle adjustment procedures are found on the underhood decal on most new vehicles.

____ 31. Idle mixture adjustment on vehicles without emission control is a difficult task.

____ 32. Using the wrong type of gasket sealer on intake manifolds will damage the O sensor.

____ 33. The tightening sequence used to install the intake manifold is of little importance.

____ 34. After the intake manifold has been reinstalled on the engine, the installation should be checked for fuel, oil, and coolant leaks.

____ 35. The coolant should be drained before the intake manifold is removed.

SECTION B. Read each of the below statements made by Technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.

____ 36. TECHNICIAN I says always to check for signs of binding or sticking throttle linkage when installing a carburetor.

TECHNICIAN II says always to check and adjust the engine timing before adjusting the carburetor.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 37. TECHNICIAN I says that a rich air/fuel mixture will cause a low rpm drop during the propane enrichment test.

TECHNICIAN II says that, if the air/fuel mixture is too rich, the idle speed screw should be turned in 1/2 a turn.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 38. TECHNICIAN I says that care should be taken when cleaning aluminum intake manifolds because these manifolds warp very easily.

TECHNICIAN II says that exhaust crossover passages in the intake manifold do not need to be inspected.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

(NOTE: The student must obtain a minimum score of _____ on Part III of the Unit III Test in order to receive an evaluation for Competencies K4 and K7.)

ANSWERS TO UNIT III TEST

1. t
2. f
3. t
4. f
5. f
6. c
7. d
8. a
9. t
10. t
11. f
12. f
13. t
14. t
15. t
16. f
17. e
18. b
19. e

18. f
19. b
20. d
21. d
22. c
23. b
24. a
25. c
26. c
27. f
28. f
29. t
30. f
31. f
32. t
33. f
34. t
35. t
36. a
37. c
38. d

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT IV: GASOLINE ENGINE ELECTRONIC FUEL INJECTION

UNIT OBJECTIVE

After completing this unit, the student should be able to identify components of electronic fuel injection systems and service electronic fuel injection systems. The student will demonstrate mastery of the material by achieving a score of ______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1. I. Identify terms and definition associated with electronic fuel injection systems (Competencies K1, K5, K6, and K7, Part I of the Unit IV Test).

II. Identify the advantages of the fuel injection system (Competencies K1, K5, K6, and K7, Part I of the Unit IV Test).

III. Identify the different types of fuel injection systems (Competencies K1, K5, K6, and K7, Part I of the Unit IV Test).

IV. Identify the difference between timed and continuous fuel injection (Competencies K1, K5, K6, and K7, Part I of the Unit IV Test).

V. Identify the various components of a fuel injection system (Competencies K1, K5, K6, and K7, Part I of the Unit IV Test).

VI. Identify the operating principles of throttle body fuel injection (Competencies K1, K5, K6, and K7, Part I of the Unit IV Test).

VII. Identify the operating principles of port fuel injection (Competencies K1, K5, K6, and K7, Part I of the Unit IV Test).

VIII. Identify the operating principles of Bosch K-Jetronic continuous injection (Competencies K1, K5, K6, and K7, Part I of the Unit IV Test).

Lesson 2. I. Identify the procedures for diagnosing electronic fuel injection system problems (Competency K1, Part II of the Unit IV Test).

II. Identify the procedures for cleaning and inspecting fuel injector components (Competency K5, Part III of the Unit IV Test).

III. Identify procedure for replacing a throttle body injector (Competency K6, Part IV of the Unit IV Test).

IV. Identify the procedure for removing and installing a port injector and fuel rail (Competency K6, Part IV of the Unit IV Test).

V. Identify the procedures for removing, cleaning, inspecting, and reinstalling the throttle body (Competency K6, Part IV of the Unit IV Test).

VI. Identify the procedures for checking the minimum idle speed (Competency K7, Part V of the Unit IV Test).

VII. Demonstrate the ability to:

   a. Diagnose electronic fuel injection problems (Competency K1, JS1-L2-UIV).

   b. Replace throttle body fuel injectors (Competency K6, JS2-L2-UIV).

   c. Replace port injection type fuel injector and fuel rail (Competency K6, JS3-L2-UIV).

   d. Remove and install the throttle body (Competency K6, JS4-L2-UIV).

   e. Adjust throttle body minimum idle speed (Competencies K5 and K7, JS5-L2-UIV).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks H029, H037, H043, H045, and H046.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT IV: GASOLINE ENGINE ELECTRONIC FUEL INJECTION

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: ELECTRONIC FUEL INJECTION CONSTRUCTION AND OPERATION

    a. Information outline

    b. Assignment sheet

    AS1-L1-UIV: Electronic Fuel Injection Construction and Operation

2. Lesson 2: SERVICING ELECTRONIC FUEL INJECTION SYSTEMS

    a. Information outline

    b. Assignment sheets

    AS1-L2-UIV: Procedure for Diagnosing Electronic Fuel Injection
    AS2-L2-UIV: Procedure for Removing and Installing a Throttle Body Injector
    AS3-L2-UIV: Procedure for Removing and Installing a Port Injector and Fuel Rail
    AS4-L2-UIV: Procedure for Removing and Installing the Throttle Body
    AS5-L2-UIV: Procedure for Adjusting Throttle Body Minimum Idle Speed

    c. Job sheets:

    JS1-L2-UIV: Diagnosing Electronic Fuel Injection
    JS2-L2-UIV: Removing and Installing a Throttle Body Injector
    JS3-L2-UIV: Removing and Installing a Port Injector and Fuel Rail
    JS4-L2-UIV: Removing and Installing the Throttle Body
    JS5-L2-UIV: Adjusting Throttle Body Minimum Idle Speed

E. Unit test

F. Answers to unit test

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NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L2-UIV in conjunction with JS1-L2-UIV; AS2-L2-UIV in conjunction with JS2-L2-UIV; AS3-L2-UIV in conjunction with JS3-L2-UIV; AS4-L2-UIV in conjunction with JS4-L2-UIV; and AS5-L2-UIV in conjunction with JS5-L2-UIV.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT IV: GASOLINE ENGINE ELECTRONIC FUEL INJECTION

LESSON 1: ELECTRONIC FUEL INJECTION CONSTRUCTION AND OPERATION

I. Terms and definitions

A. ECM--Abbreviation which stands for electronic control module. ECM is the computer that controls engine fuel, ignition, and emissions based on input from various sensors.

B. CFI--Abbreviation which stands for central fuel injection. CFI refers to a type of throttle body injection.

C. Multi-point injection--Same as port fuel injection.

D. PFI--Abbreviation which stands for port fuel injection. PFI is a fuel system that has a separate injector for each cylinder in the engine.

E. TBI--Abbreviation which stands for throttle body injection. TBI is a fuel injection system having one or two injectors mounted on a throttle body. Air and fuel are both distributed through the intake manifold from the throttle body.

II. Advantages of electronic fuel injection

A. The majority of new, gasoline-engine cars and light trucks produced today are equipped with an electronic fuel injection system. Strict federal regulations imposed over the last few years concerning exhaust emissions and fuel economy created the need for a system that would provide greater control over the air/fuel ratio. Electronic fuel injection has taken the place of the carburetor (including the electronic feedback carburetor) on most vehicles; electronic fuel injection controls the air/fuel ratio required by the vehicle.

B. Advantages of fuel injection

1. Fuel injection improves fuel economy.

2. Fuel injection allows for leaner air/fuel ratios for improved emissions.

3. Fuel injection makes throttle response faster because the fuel is under pressure at the injector at all times. Throttle response does not rely on changes in air pressure as in a carbureted system. As soon as the injector is opened, fuel sprays out instantly.

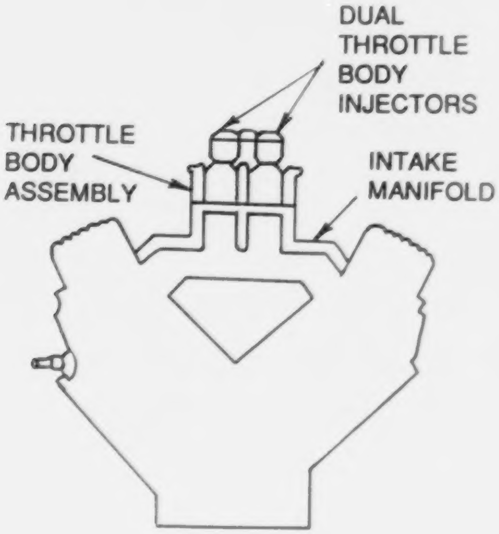
4. Fuel injection practically eliminates exhaust emissions during deceleration. Fuel injection systems are designed to shut off fuel when the throttle is released and the car decelerates. This also results in fuel savings.

III. Types of fuel injection systems

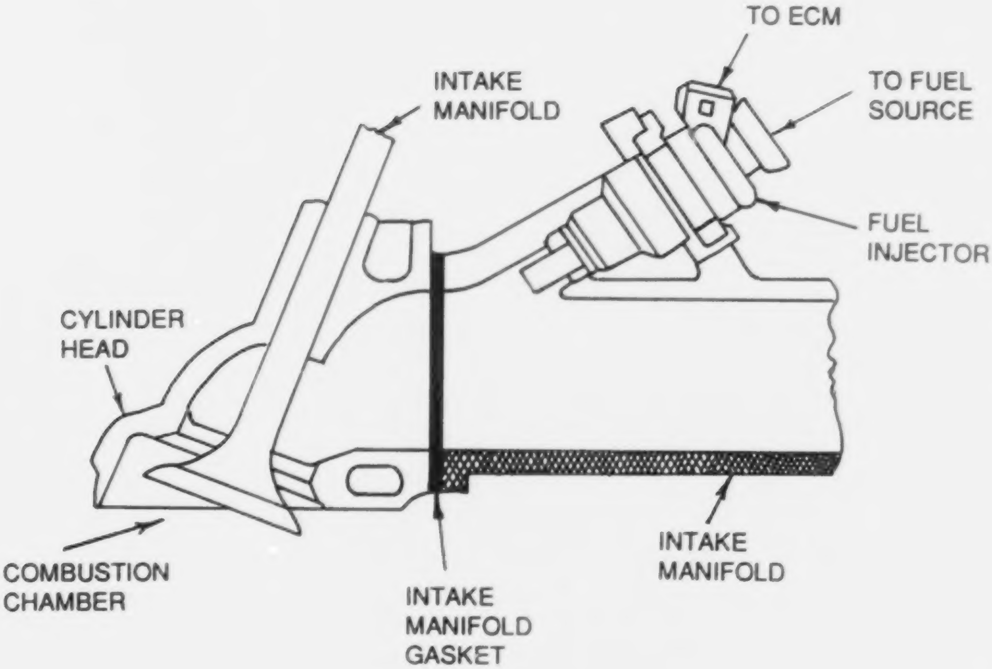
A. Direct fuel injection is used on diesel engines. In the direct injection system, fuel is injected directly into the combustion chambers. Direct injection systems will be discussed in a later unit.

B. Intake manifold injection is used in most gasoline engines. In the intake manifold system, fuel is injected into the air approaching the cylinder head intake port. Manifold injection can be accomplished by throttle body or port injection.

1. In the throttle body injection (TBI) system, fuel is injected into a throttle body. Fuel is then delivered through a manifold in much the same way as in a carbureted system. One or two injectors are mounted in a throttle body assembly; the injector or injectors feed all cylinders through the intake manifold.


DUAL THROTTLE BODY INJECTORS
THROTTLE BODY ASSEMBLY
INTAKE MANIFOLD

2. In the port fuel injection (PFI) system, fuel is injected into the intake manifold near each intake valve. Separate injectors are provided for each cylinder.


TO ECM
INTAKE MANIFOLD
TO FUEL SOURCE
FUEL INJECTOR
CYLINDER HEAD
COMBUSTION CHAMBER
INTAKE MANIFOLD GASKET
INTAKE MANIFOLD

IV. Fuel can be injected either on a timed or continuous basis.

A. In the timed injection method, fuel is sprayed into the combustion chamber at the right moment. The time of injection must change as engine speed changes. Different variations of timed fuel injection systems are used in electronic port fuel injection (PFI). These variations include sequential and grouped injection.

1. In sequential PFI, each injector operates individually. Each injector is opened by the ECM just before the intake valve opens for maximum performance.

2. In grouped injection, two or more injectors are "fired" at the same time during each crankshaft revolution. In a design of this type, the fuel charge lies in the intake manifold for a period of time until the intake valve opens.

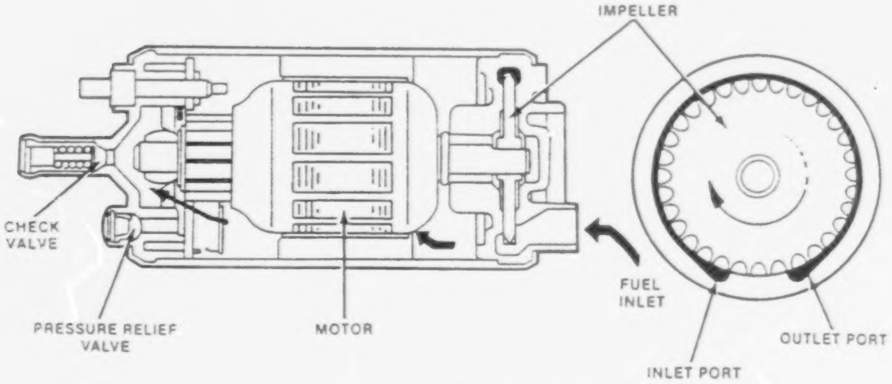
B. In continuous injection, there is a constant discharge from the injector. The amount of fuel sprayed varies with engine speed and power demands. This system is simpler and less expensive than timed injection because it does not require an electronic control system to govern the length of injection in relation to operating conditions.

V. Fuel injection system components

A. High-pressure electric fuel pump

1. The fuel pump is generally mounted inside the fuel tank. On some vehicles, however, the pump is located in the fuel line between the gas tank and the pressure regulator. Pump pressure varies in port injected engines.

2. The vane and roller type pumps are the designs most commonly found on today's cars. Current flow to the pump is directed through a fuel pump relay.



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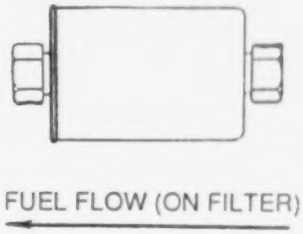
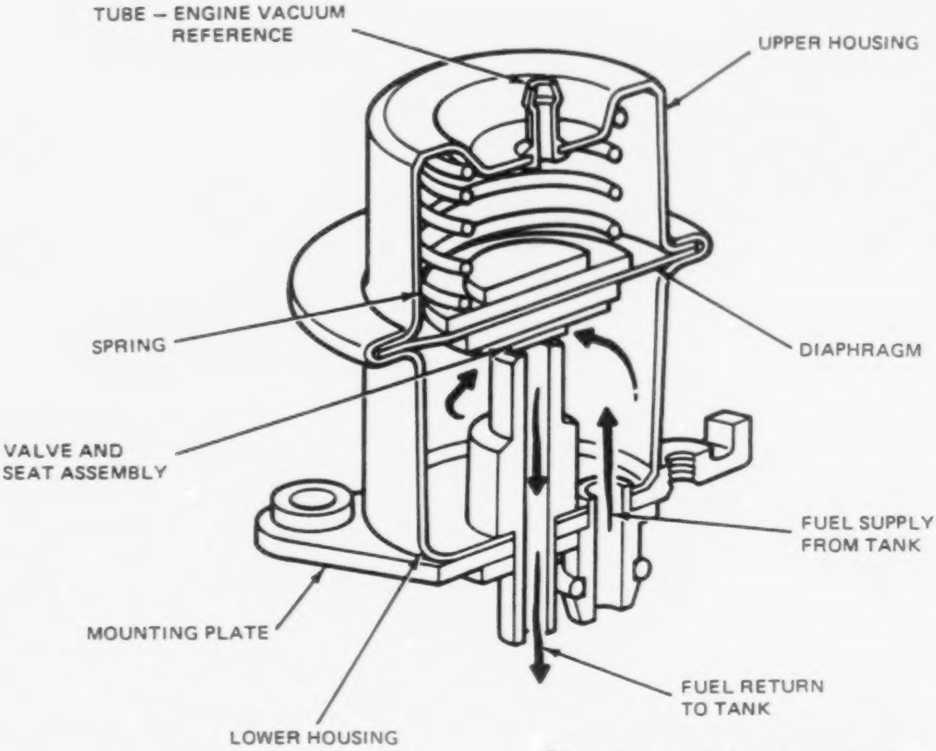
B. Fuel filter

1. An in-tank filter (sock) is mounted on the pump inlet of the in-tank pump or on the pick-up tube of an externally mounted pump.
2. An in-line filter is generally mounted under the vehicle or in the engine compartment between the pump and injector assembly.


FUEL FLOW (ON FILTER)

C. Two different types of fuel pressure regulators are used for TBI and PFI units.


TUBE – ENGINE VACUUM REFERENCE
UPPER HOUSING
SPRING
DIAPHRAGM
VALVE AND SEAT ASSEMBLY
FUEL SUPPLY FROM TANK
MOUNTING PLATE
FUEL RETURN TO TANK
LOWER HOUSING

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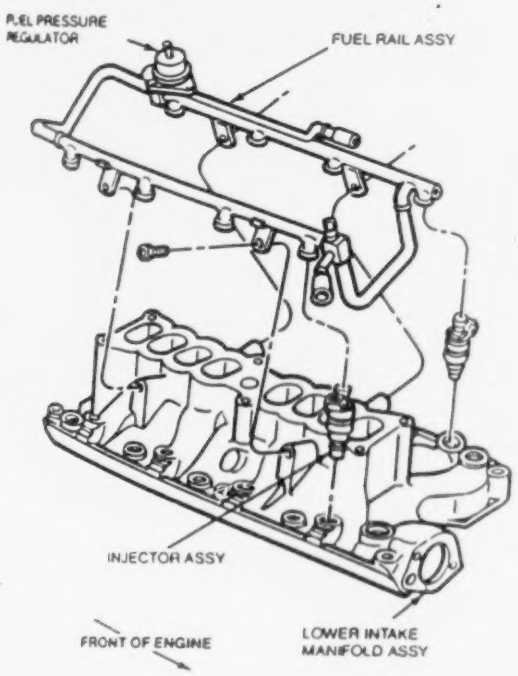
D. Fuel supply and return lines

1. Fuel supply and return lines deliver fuel from the tank to and from the fuel rail.
2. Rubber and plastic lines used in electronic fuel injection systems must be capable of withstanding much higher pressures than lines used in carbureted systems.

E. Fuel rail

1. The fuel rail consists of metal lines that connect the fuel supply line to the injectors of PFI systems.
2. The fuel pressure regulator is an integral part of the rail on some applications.



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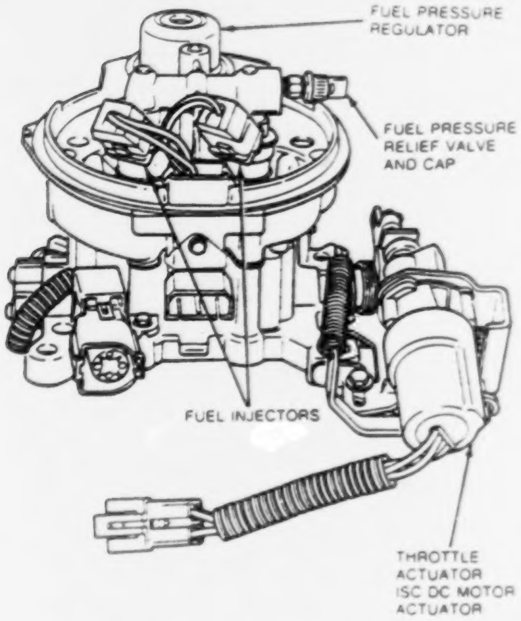
F. Throttle body

1. The throttle body is a throttle valve assembly that is actuated by the accelerator. On throttle body injected engines, the injector(s) is positioned above the throttle plate. On port injected engines, the throttle body is for air control only.
2. The throttle body contains the components listed below.
    a. A throttle position sensor signals the amount of throttle opening to the ECM.
    b. The idle speed motor is an electric motor that controls an air passage that governs idle speed according to output from the ECM.
    c. Depending on its design, the throttle body contains other devices.


FUEL PRESSURE REGULATOR
FUEL PRESSURE RELIEF VALVE AND CAP
FUEL INJECTORS
THROTTLE ACTUATOR ISC DC MOTOR ACTUATOR

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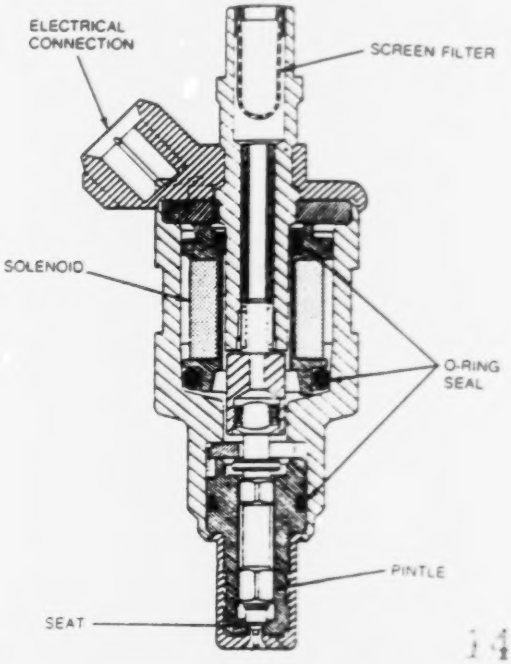
G. Fuel injector

1. A fuel injector is an electromagnetic device containing a solenoid which, upon receiving an electrical signal from the ECM, pulls a plunger or core piece upward.
2. The upward movement of the core allows a spring-loaded ball valve to come off the valve seat. This permits fuel to flow to the spray nozzle.
3. A fine screen filters impurities before the fuel reaches the spray nozzle.
4. After the reaching the spray nozzle, the fuel is sprayed into the throttle body or intake port.


ELECTRICAL CONNECTION
SCREEN FILTER
SOLENOID
O-RING SEAL
PINTLE
SEAT

H. Injector timing/triggering

1. Whether sequential or grouped injection, all port type electronic fuel injection systems must signal to the ECM when to fire each injector according to crankshaft position.

2. Triggering of the injectors is commonly accomplished through the use of a Hall switch. A Hall switch is generally preferred over the magnetic pickup because the Hall switch is more precise at low speeds. The Hall switch may be mounted in the distributor along with another Hall switch or magnetic pick-up for triggering of the ignition.

VI. Throttle body fuel injection (TBI)

A. Throttle body fuel injection is a relatively simple system in which fuel is delivered from the fuel tank by an electric fuel pump to a "throttle body" containing one or two injectors. In fact, compared to many "newer" carburetors that contain a maze of electrical and vacuum controls, an electronic throttle body fuel injection system may seem simple. The most complex components of any electronic fuel injection are housed inside of the ECM.

B. Operation of the throttle body fuel injection system

1. On the way to the throttle body, the fuel passes through a fuel filter. Fuel pressure is kept even by a regulator.

2. Air/fuel mixture is controlled by input relayed from various sensors to the electronic control unit. The electronic control unit, in turn, controls injector fuel flow. Listed below are the sensors that relay input to the electronic control unit.

a. Oxygen sensor

b. MAP sensor

c. Coolant sensor

d. Throttle position sensor

C. The typical throttle body consists of a pressure regulator, fuel injector, throttle position sensor, and either an idle air control or an idle speed control.

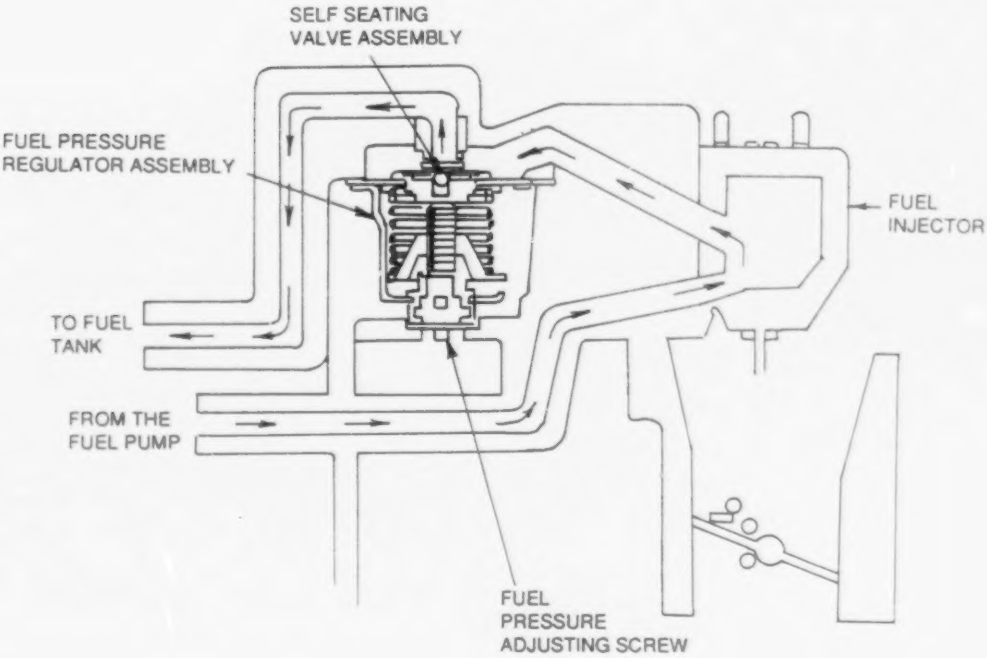
1. Pressure regulator

a. The pressure regulator on TBI units is housed in the throttle body assembly.

b. The type of regulator used in TBI systems contains a fuel chamber and an air chamber, which are separated by a diaphragm-operated relief valve and a calibrated spring.

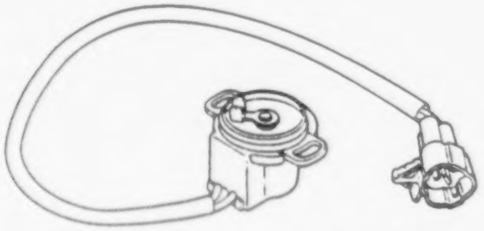
c. Fuel pressure is regulated by the difference between fuel pump pressure acting on one side of the diaphragm and the force of the calibrated spring acting on the other side.

d. If fuel pressure is below specification, the calibrated regulator spring forces the diaphragm and relief valve assembly up toward an opening in the passage, effectively reducing fuel flow to the fuel return line and allowing fuel inlet pressure to build up.


SELF SEATING
VALVE ASSEMBLY
FUEL PRESSURE
REGULATOR ASSEMBLY
FUEL
INJECTOR
TO FUEL
TANK
FROM THE
FUEL PUMP
FUEL
PRESSURE
ADJUSTING SCREW

2. One or two fuel injectors are mounted above the throttle plate(s). Injector operation is controlled by the ECM.

3. The throttle position sensor (TPS) is a potentiometer that is mounted on the throttle body. The TPS moves as the throttle is opened and closed, varying the input voltage signal to the ECM. Input from the TPS helps to control the air/fuel mixture.



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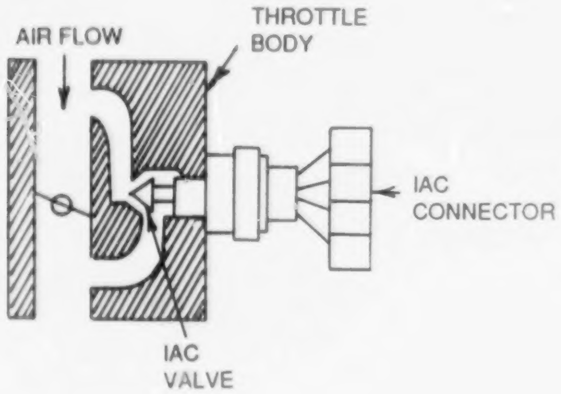
4. Idle air control (IAC)

a. The IAC is an electrical device that controls idle speed and prevents stalling, which may occur due to changes in engine load. The IAC is mounted in the throttle body and controls bypass air around the throttle plate(s).

b. By moving a conical valve (called a pintle) in to decrease air flow or out to increase air flow, the IAC controls the amount of air moving around the throttle plates.

c. If rpm is too low, more air is bypassed around the throttle valve to increase rpm. If rpm is too high, less air is bypassed around the throttle valve to decrease rpm.

d. To control rpm as needed, the ECM monitors engine rpm and provides output to the IAC.

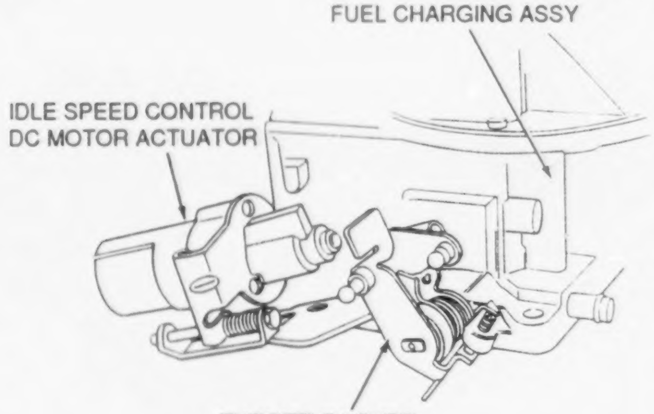

AIR FLOW
THROTTLE BODY
IAC CONNECTOR
IAC VALVE

5. Idle Speed Control (ISC)

a. ISC is a direct current motor actuator. The ISC controls idle speed by modulating the throttle lever for the airflow needed to maintain the desired engine rpm for both warm engine and for the additional engine speed required during cold engine idle.

b. An idle tracking switch is integral with the DC motor. The switch determines when the throttle lever has contacted the actuator, thereby, signalling the need to control engine rpm.

c. The DC motor extends or retracts a linear shaft through a gear reduction system. The motor direction is determined by the polarity of the applied voltage.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FUEL CHARGING ASSY
IDLE SPEED CONTROL DC MOTOR ACTUATOR
THROTTLE LEVER

VII. Port fuel injection (PFI)

A. A throttle body is also used in the PFI system; however, no fuel injectors are located in the throttle body. The injectors in the PFI system (there is one injector for each cylinder) are placed in the intake manifold near the intake valve.

B. PFI provides better fuel distribution than does a throttle body injection system. PFI components include the throttle body, idle air control, fuel pressure regulator, and input sensors.

   1. Unlike the throttle body injection, the job of the throttle body in this system is to control air only. Throttle valves are opened and closed in response to accelerator movement.

   2. An idle air control (IAC) valve, similar to those found on throttle body injection systems, is normally found in a PFI throttle body. Appearance and operation of this valve are similar to those previously described.

   3. Fuel pressure regulator

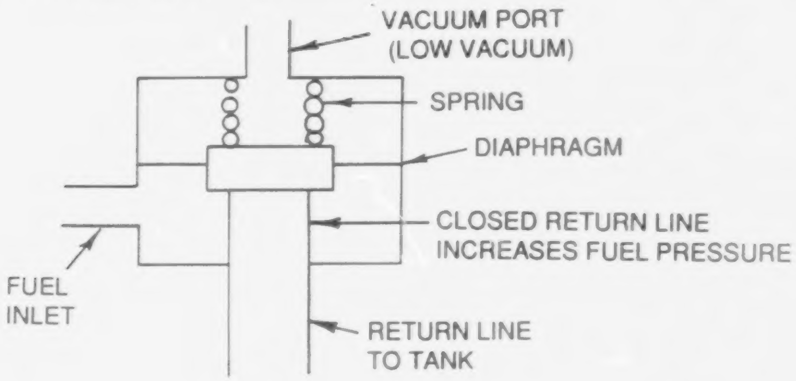
      a. The type of fuel pressure regulator commonly used in PFI systems contains a pressure chamber that is separated by a diaphragm relief valve assembly with a calibrated spring on the vacuum chamber side.

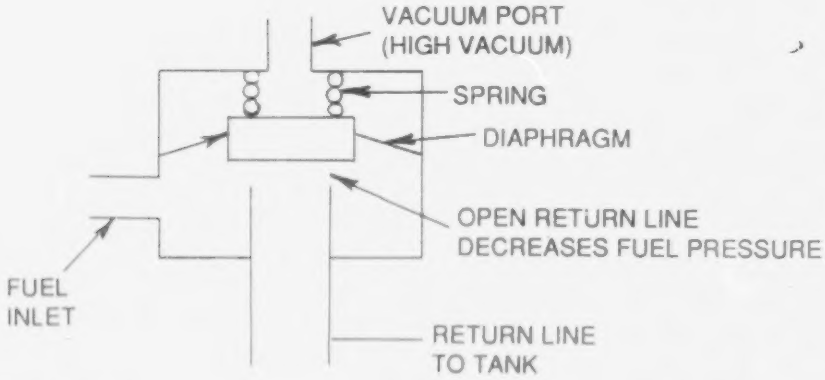
      b. Fuel pressure is regulated when pump pressure, acting on the bottom side of the diaphragm, overcomes the force of the spring action on the top side.

      c. The diaphragm relief valve moves, opening or closing an orifice in the fuel chamber to control the amount of fuel returned to the fuel tank.

      d. Vacuum, acting on the top side of the diaphragm along with spring pressure, controls fuel pressure.

e. A decrease in vacuum creates an increase in fuel pressure. An increase in vacuum creates a decrease in fuel pressure. For example, under heavy load conditions, the engine requires more fuel flow. Vacuum decreases under heavy load conditions because of throttle opening. A decrease in vacuum allows more pressure to the top side of the pressure relief valve, thus increasing fuel pressure.


VACUUM PORT
(LOW VACUUM)
SPRING
DIAPHRAGM
CLOSED RETURN LINE
INCREASES FUEL PRESSURE
FUEL
INLET
RETURN LINE
TO TANK


VACUUM PORT
(HIGH VACUUM)
SPRING
DIAPHRAGM
OPEN RETURN LINE
DECREASES FUEL PRESSURE
FUEL
INLET
RETURN LINE
TO TANK

4. Input sensors

(NOTE: For sensor description, see the final unit of Ignition Systems, Section A of the Engine Performance Module.)

a. MAP

b. TPS

c. Mass air flow sensor

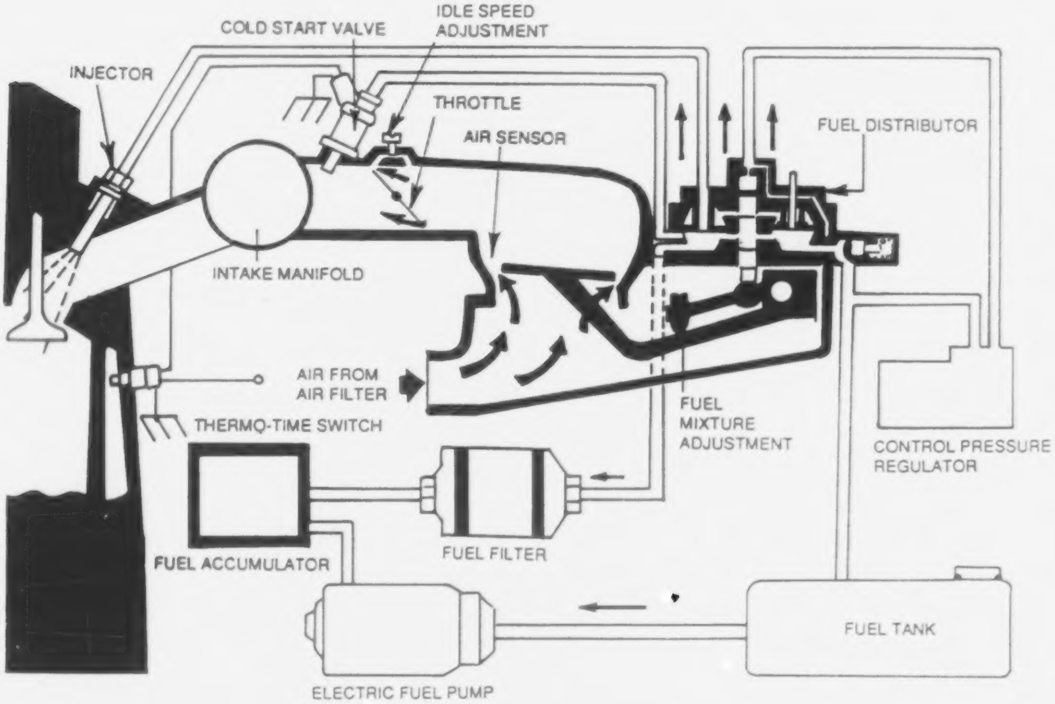
d. Coolant sensor

e. Hall switch (for injector timing)

VIII. Bosch K-Jetronic continuous injection system

A. The Bosch K-Jetronic continuous injection system differs from the electronic systems previously discussed in that it is basically a mechanical system. One of the system's few electrical parts is the electric fuel pump, which is similar to those used in other systems. Late model systems have incorporated an O_2 sensor and a computer to regulate air/fuel mixture so that a three-way catalyst might be used.

B. In the Bosch K-Jetronic continuous injection system, fuel flow to the injectors is controlled by a fuel distributor that feeds fuel to the engine in amounts proportional to air flow into the engine. The fuel is delivered to the injectors under constant pressure. The amount of fuel delivered to the injectors is varied as opposed to varying the injector pulse width as in electronic systems.


COLD START VALVE
IDLE SPEED ADJUSTMENT
INJECTOR
THROTTLE
AIR SENSOR
FUEL DISTRIBUTOR
INTAKE MANIFOLD
AIR FROM AIR FILTER
THERMO-TIME SWITCH
FUEL MIXTURE ADJUSTMENT
CONTROL PRESSURE REGULATOR
FUEL ACCUMULATOR
FUEL FILTER
FUEL TANK
ELECTRIC FUEL PUMP

C. Operation of the Bosch K-Jetronic continuous injection system

1. Air enters through an air filter and is measured by an air flow sensor.

2. Air flow is controlled by a throttle valve as in a carbureted system or any of the other fuel injection systems previously discussed. Air flows past the open throttle valve, through the intake manifold and into the combustion chambers past the intake valves as they open.

3. Fuel is delivered by an electric fuel pump, through an accumulator and fuel filter to the fuel distributor.

4. Air, acting on the air flow sensor plate, raises a control plunger in the fuel distributor. The greater the air flow, the more the control plunger is raised, allowing more fuel flow to the injectors.

5. Fuel flows from the distributor to the injectors and is then sprayed into the intake as the engine runs. A constant spray of fuel is maintained.

6. Fuel will remain in the intake runners until the intake valves open, drawing fuel into the combustion chambers.

7. A cold start valve or injector is used to enrich the air/fuel mixture during cold engine operation. The valve or injector sprays additional fuel into the intake until the engine warms to a predetermined temperature.

D. Adjusting the Bosch K-Jetronic continuous injection system

1. Unlike most PFI systems, the idle speed and mixture are adjustable on the Bosch K-Jetronic continuous injection system.

2. Idle speed is adjusted by varying the opening in an air bypass passage around the throttle valve.

3. Idle mixture is changed by varying the relationship between the air sensor level and the fuel distributor plunger.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

ELECTRONIC FUEL INJECTION CONSTRUCTION AND OPERATION

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. List two types of manifold injection.

2. Port type fuel injection systems use how many injectors per cylinder?

3. What fuel injection sensor device is a potentiometer?

4. What fuel injection system provides better fuel distribution than throttle body systems?

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

ELECTRONIC FUEL INJECTION CONSTRUCTION AND OPERATION

(ANSWER SHEET)

1. Throttle body and port
2. One
3. The throttle position sensor
4. Port fuel injection systems

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT IV: GASOLINE ENGINE ELECTRONIC FUEL INJECTION

LESSON 2: SERVICING ELECTRONIC FUEL INJECTION SYSTEMS

I. Diagnosing electronic fuel injection systems

  A. A large part of electronic fuel injection problems can be solved through the use of on-board diagnostics. Engine control systems with built-in diagnostics can be very helpful in diagnosing problems. (See Section A of the Engine Performance Module for details concerning on-board diagnostics and fault codes.)

  B. Visual inspection

    1. The diagnostic procedure should begin with a visual inspection of the fuel injection system along with other engine systems. Do not neglect checking the ignition system, cooling system, general engine condition, etc. The technician must realize that, in a computer-controlled engine, the performance of each component and system is dependent on the performance of the rest of the system.

    2. Procedure for inspecting the fuel injection system and other engine systems

      a. Inspect all fuel lines and hoses for leakage, crimping, deterioration, etc.

      b. Check all wire connectors for a snug fit.

      c. Check condition of all vacuum hoses. (A vacuum leak will result in a lean mixture possibly resulting in a misfire.)

      d. Check condition and routing of spark plug wires and other ignition components.

      e. Inspect condition of air filter.

      f. Check condition of air induction system. (A torn induction hose could cause air to bypass the mass air flow sensor, sending incorrect signals to the computer.)

      g. Inspect all emission-control devices for proper installation and operation.

      h. Inspect coolant level and condition.

  C. If on-board diagnostics and visual tests do not provide clues to performance problems, using an engine analyzer to perform the following tests may prove helpful. (See Section A of the Engine Performance Module for details on the use of an analyzer.)

    1. Check engine base timing.

    2. Perform oscilloscope tests.

    3. Perform cylinder balance test.

    4. Perform infrared exhaust analysis.

D. Fuel pressure test

1. A pressure test is important in determining if adequate fuel is being delivered to the fuel injectors.

2. This procedure is outlined in JS3-L2-UI of Section A of the Engine Performance Module.

E. Testing the injector

1. Voltage at each injector can be checked on most systems with an high-impedance voltmeter or special test light called a noid. Below is an outline of the procedure.

    a. Disconnect the electrical connector from the injector.

    b. Connect a high-impedance voltmeter or a noid to the wiring harness connector.

    c. Crank the engine while observing the voltmeter or noid.

    d. The voltmeter or noid should flicker rapidly as the engine is cranked. This means the injector is receiving electrical signals from the ECM.

2. Using an ohmmeter and the following procedure, the injector itself can be checked for short circuits, opens, and grounds.

    a. To test for shorts and opens, connect an ohmmeter across the two injector terminals and compare to factory resistance specifications.

    b. To test for grounds, connect the ohmmeter from one injector terminal to the injector body.

F. Testing injector balance (port injection only)

1. The following test can be performed only on port type fuel injection systems. If the engine is running rough or missing, this test indicates if each injector is doing its job. This test will help locate an injector that is not functioning properly. Below is the procedure for the test.

    (NOTE: The injector test should be performed first to eliminate the possibility of electrical malfunctions. If an injector is still not functioning properly after passing the electrical tests, the problem is likely a dirty injector nozzle.)

    (NOTE: The following test will not work on all fuel injection systems. Check manufacturer's service manual before performing this test.)

    a. Connect a tachometer and fuel pressure gauge to the engine.

    b. Start engine and run it until it reaches operating temperature.

    c. Unplug each injector one at a time and note tachometer and pressure gauge readings.

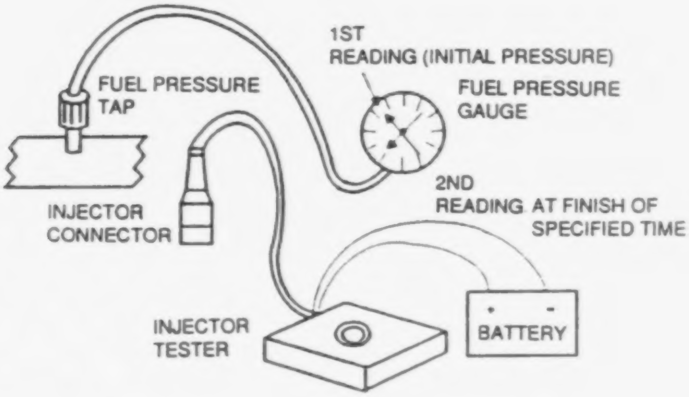
        (NOTE: Idle speed control motor must be disconnected, or it will attempt to compensate for the disconnected injector by raising idle speed.)

    d. Allow pressure and engine speed to stabilize before proceeding to the next cylinder.

e. Pressure gauge and tachometer should drop about the same amount for each cylinder. If disconnecting an injector has little effect, the injector is either dirty or is malfunctioning electrically.

(NOTE: All mechanical, vacuum, and ignition problems should be eliminated before performing this test.)

2. Another type of injector balance test may be performed using a special tool to activate each injector for a specified and equal amount of time. While the injector is activated, a pressure gauge is used to detect any pressure drop.



II. If the technician determines that the fuel injectors are functioning electrically but not permitting fuel flow, the technician should clean the fuel injectors. Equipment for cleaning fuel injectors varies considerably.

A. One of the simplest types of cleaner is a pressurized can of cleaning solvent that is attached to the fuel injector(s) through a special hose and adaptor.

1. After the engine is brought to operating temperature, the vehicle fuel pump is disabled to prevent fuel in the tank from reaching the injector.

(NOTE: The fuel return line must also be blocked to prevent contamination of the fuel tank.)

2. The engine is started and fueled by the injector cleaner. When the container is emptied, the engine will stall.

3. The cleaner adaptor is then removed and all components are restored to normal operation.

4. The engine should then be restarted and the system checked for fuel leakage.

B. Another type of cleaner uses a pressurized container with a mixture of special injector cleaner and clean gasoline.

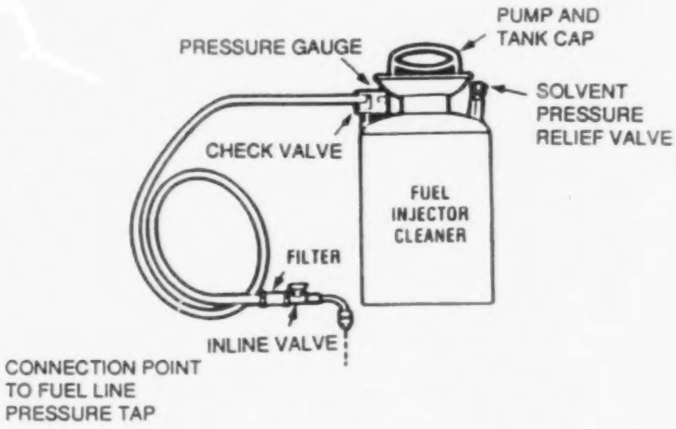
1. The pump on the container is operated until gauge pressure is 25 psi.

2. The container is attached to the injectors, the fuel pump is disabled, and the fuel return is blocked.

(NOTE: The fuel return line must also be blocked to prevent contamination of the fuel tank.)

3. The engine is then started and run at 2000 rpm for 10 to 20 minutes (depending on engine).

4. The engine is then shut off and the cleaner disconnected.


PUMP AND
TANK CAP
PRESSURE GAUGE
SOLVENT
PRESSURE
RELIEF VALVE
CHECK VALVE
FUEL
INJECTOR
CLEANER
FILTER
INLINE VALVE
CONNECTION POINT
TO FUEL LINE
PRESSURE TAP

C. A third type of cleaner uses an electric pump and pressure regulator. Operation and hook up is similar to the hand-operated device previously discussed.

III. Replacing throttle body injector

A. Procedure for removing the injector

(NOTE: Due to differences in manufacturer's designs, procedures for removing an injector will vary. Consult the proper service manual when working on a particular vehicle.)

1. Disconnect negative battery cable.

2. Relieve fuel system pressure. (See Unit I of this section of the Engine Performance Module and the appropriate service manual for this procedure.)

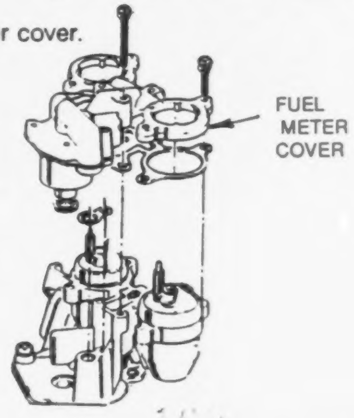
   (**CAUTION:** Automotive fuel is highly flammable. Do not service fuel systems in the presence of sparks or open flame. Store fuel in approved, sealed containers. Immediately clean up any fuel spill.)

3. Disconnect electrical connector from fuel injector.

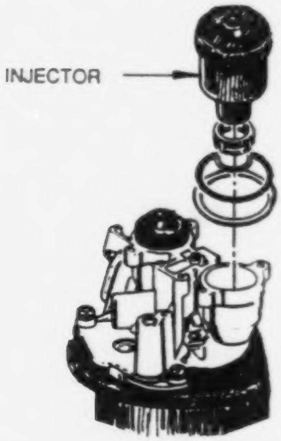
4. Remove fuel metering cover assembly.

   a. Remove screws holding fuel meter cover assembly to throttle body.

   b. Remove fuel meter cover.


FUEL
METER
COVER

5. Leave fuel meter cover gasket in place to prevent damage to the casting. Use a screw driver and fulcrum to pry the injector out of the throttle body.



6. Remove and discard the upper and lower o-rings that seal the injector to throttle body. Remove and discard fuel metering cover gasket.

B. Procedure for inspecting the injector

1. Inspect fuel injector for evidence of dirt or other contamination. If found, check filter, tank and lines for contaminated fuel.

2. Inspect fuel meter cover and throttle body for damage or warpage. Replace if found defective.

C. Procedure for installing the injector

1. Make sure the proper fuel injector is being installed. Identical looking injectors can have different flow rates, which will affect performance. Check the injector part number against manufacturer's specifications before installing the injector.

2. Lubricate injector o-rings with a light grease and install them on injector. Make sure o-rings are properly seated.

3. Align injector in the throttle body and push down on the injector until it is fully seated.

   (**CAUTION:** Make sure the alignment pin is aligned with the slot in the casting.)

4. Install fuel meter cover gasket and cover.

5. Tighten fuel meter cover to specified torque.

6. Connect electrical connector to fuel injector.

7. Reconnect battery cable. Turn ignition key on, but do not start the engine. This will cause the fuel pump to run and pressurize the fuel system. Check the throttle body and injector for fuel leakage. Correct leakage if found.

8. Connect exhaust ventilation equipment to the vehicle exhaust, start the engine, and check injector operation.

IV. Removing and installing A port injector and fuel rail

(NOTE: Procedures for replacing port type fuel injectors will vary depending on manufacturer and design. The number of components that must be removed to gain access to the injectors will also vary. Consult the appropriate service manual when working with a specific vehicle.)

A. Procedure for removing fuel rail assembly

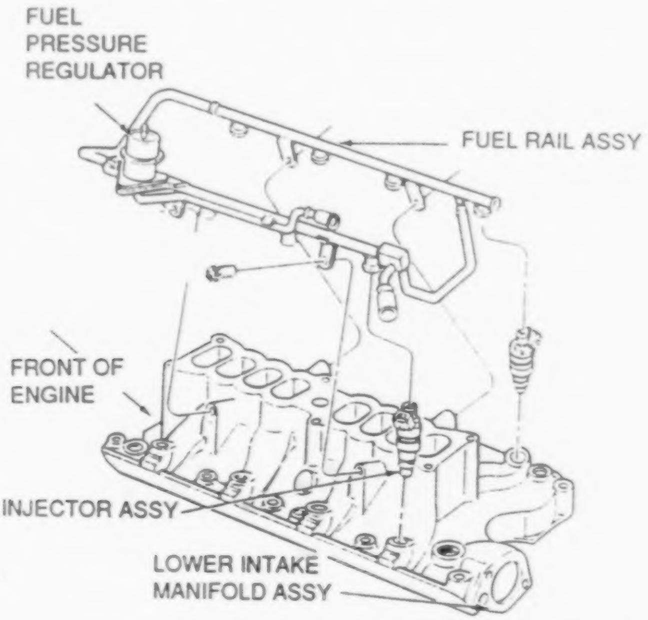
(**CAUTION:** Automotive fuel is highly flammable. Do not service fuel systems in the presence of sparks or open flame. Store fuel in approved, sealed containers. Immediately clean up any fuel spill.)

1. Disconnect negative battery cable.
2. Relieve system pressure. (See Unit 1 of this section of the Engine Performance Module and the appropriate service manual for this procedure.)
3. Disconnect fuel line from fuel rail.
4. Remove bolts retaining fuel rail.
5. Carefully lift the fuel rail from the fuel injectors and remove the fuel rail. Use a rocking, side-to-side motion to remove the injectors from the fuel rail.

(NOTE: It is sometimes easier to remove the fuel rail and injectors as an assembly.)

B. Procedure for removing injector

1. Disconnect the electrical harness connectors from each injector to be removed.
2. Remove injector(s) from the intake manifold. (If injectors were removed with fuel rail, remove the injectors from the rail.) Gently rocking the injector from side to side while pulling upward makes removal easier.



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C. Procedure for inspecting injector

1. Inspect condition of injector o-rings. Replace o-rings if they are damaged or deteriorated.
2. Inspect electrical connector for damage.
3. Inspect protective cap covering nozzle and pintle valve. This cap can come off and fall into the intake manifold.

D. Procedure for installing injector and fuel rail

1. Replace damaged or deteriorated o-rings. Lubricate o-rings with automatic transmission fluid and install on injector.
2. Install injector(s). Use a light twisting and pushing motion to install.
3. Install fuel rail in reverse order of disassembly.

   (NOTE: When installing fuel rail, be certain all injectors are started straight. Forcing assembly with an injector not properly aligned may damage the injector and/or the fuel rail.)

4. Reconnect all wiring harness connectors to the fuel injectors.
5. Reconnect battery cable. Do not start engine, but turn key to the run position. This charges (pressurizes) the fuel injectors. Inspect for fuel leakage at all connections and correct immediately if found.
6. Connect exhaust ventilation equipment to vehicle exhaust, start vehicle and check for proper engine operation.

V. Removing, cleaning, inspecting, and reinstalling the throttle body

A. Procedure for removing the throttle body

(NOTE: The procedure for removing the throttle body will vary depending on manufacturer and design. Consult the proper service manual when working with a specific vehicle.)

1. Disconnect negative battery cable.
2. Remove air cleaner or air inlet duct.
3. Relieve fuel system pressure, following the manufacturer's recommended procedure. Also see information in Section B of the Engine Performance Module.
4. Remove electrical connector from idle speed control, throttle position sensor, and injector (if throttle body injection).
5. Disconnect accelerator cable (transmission-control cable and speed-control cable), if so equipped.
6. Disconnect fuel inlet and return line.
7. Disconnect vacuum lines. Mark vacuum lines for proper reinstallation.
8. Remove bolts/nuts retaining throttle body and remove throttle body. Place a clean towel over the intake opening to prevent foreign objects from entering the engine.

B. Procedure for cleaning and inspecting the throttle body

1. Remove old gasket, and clean mating surfaces.

2. Inspect intake manifold bore for any loose parts or foreign material that may have fallen into the manifold.

C. Procedure for installing the throttle body

1. Using a new gasket between the intake and throttle body, install the throttle body and tighten fasteners to specified torque.

2. Reconnect fuel inlet and return lines.

3. Reconnect accelerator and other cables.

4. Reconnect wiring connectors.

5. Reconnect vacuum hoses.

6. With engine off, press accelerator to the floor and release to check for binding in the accelerator.

7. With engine off and ignition on, check for leaks around fuel lines.

8. Reconnect battery and connect exhaust ventilation equipment to vehicle exhaust.

9. Start engine and check for fuel leakage and engine operation.

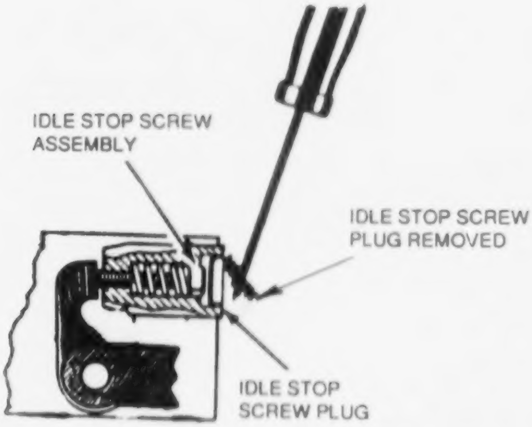
VI. Checking the minimum idle speed

A. Idle speed and mixture on an electronic fuel injected vehicle is controlled by the computer; there are no service adjustments that can be performed to change this. However, most systems do have a stop screw that maintains a minimum position of the throttle valve in the throttle bore. If this screw is incorrectly set, stalling on rapid deceleration can result. Depending on the manufacturer, this screw may or may not be adjusted.

(NOTE: The following is an example of a General Motors adjustment procedure. Consult the appropriate service manual before attempting this procedure.)

B. Procedure for checking the minimum idle speed

1. Plug the idle bypass ports, as required. Remove idle stop screw plug by prying it out with an awl.



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2. Connect a tachometer to the engine.

3. With the IAC valve connected, ground the diagnostic terminal on the ALDL connector.

4. Turn the ignition to the "on" position, but do not start engine. Wait at least 45 seconds (this allows the IAC pintle valve to extend and seat in the throttle body).

5. While the ignition is at the "on" position but the engine is not running, test terminal still grounded and disconnect IAC valve electrical connector.

6. Remove ground from the diagnostic terminal, connect exhaust ventilation equipment, and start the engine. With transmission in neutral, allow engine rpm to stabilize.

7. The tachometer should read 400 to 450 rpm. If correct reading is not obtained, adjust the idle stop speed screw accordingly.

8. Turn the ignition off and reconnect the IAC valve electrical connector.

9. Use silicon sealant or equivalent to cover minimum idle adjustment screw hole.

10. Unplug any vacuum ports.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR DIAGNOSING ELECTRONIC FUEL INJECTION

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, engine size, and year of the vehicle to be serviced.
2. Develop a written procedure for testing fuel system pressure. Determine and record specified fuel pressure.
3. Develop a written procedure for using a test light to test for current at each injector.
4. Develop a written procedure for performing an injector balance test. The procedure may be performed by using a special tester if it is available; the test may also be performed by disconnecting the injectors one at a time.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR REMOVING AND INSTALLING A THROTTLE BODY INJECTOR

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, engine size, and year of the vehicle to be serviced.
2. Develop a logically written procedure for the safe removal of the fuel injector.
3. Develop a logically written procedure for installation of the fuel injector. Determine and record any fastener torque specifications related to the installation of the injector.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR REMOVING AND REPLACING A PORT INJECTOR AND FUEL RAIL

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, engine size, and year of the vehicle to be serviced.
2. Develop a written procedure for safe removal of the fuel rail.
3. Develop a written procedure for removal of the fuel injector(s).
4. Develop a written procedure for installation of the fuel injector. Determine and record any fastener torque specifications related to the installation of the injector.
5. Develop a written procedure for installation of the fuel rail.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR REMOVING AND INSTALLING THE THROTTLE BODY

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, engine size, and year of the vehicle to be serviced.
2. Develop a logically written procedure for the safe removal of the throttle body.
3. Develop a logically written procedure for installation of the throttle body. Be sure to include all necessary specifications.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR ADJUSTING THROTTLE BODY MINIMUM IDLE SPEED

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, engine size, and year of the vehicle to be serviced.
2. Develop a logically written procedure for adjusting the minimum idle speed on the vehicle to be serviced. Be sure to include minimum idle speed specifications.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

DIAGNOSING ELECTRONIC FUEL INJECTION

Equipment:

EFI pressure gauge
Hand tools
Serviceable vehicle
Special tools as outlined in assignment sheet
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. _ _ _ _

2. Visually inspect the items listed below and record the results in the spaces provided. _ _ _ _

Fuel lines and hoses	OK____	NOT OK____
Wires and connectors	OK____	NOT OK____
Vacuum hoses	OK____	NOT OK____
Ignition components	OK____	NOT OK____
Air filter	OK____	NOT OK____
Air induction system	OK____	NOT OK____
Emission controls	OK____	NOT OK____
Coolant level and condition	OK____	NOT OK____

3. Complete AS1-L2-UIV. Following the procedure developed in item 2 AS1-L2-UIV, test fuel system pressure. Record the system specifications and the results of the test in the spaces provided below. _ _ _ _

(**CAUTION:** Be sure to use approved exhaust ventilation equipment when operating vehicle in enclosed area.)

(**CAUTION:** Automotive fuel is highly flammable . Do not service fuel systems in the presence of sparks or open flame. Store fuel in approved, sealed containers. Clean up any fuel spill immediately.)

Specified pressure ____________

System pressure ____________

4. Following the procedure developed in item 3 of AS1-L2-UIV, check for continuity at each injector. Record test results below. — — — —

5. Following the procedure developed in item 4 of AS1-L2-UIV, perform an injector balance test. Record test results below. — — — —

   a. Do all cylinders respond properly? YES____ NO____

   b. List any cylinders that do not respond properly.

*Average of above evaluations — — — —

(*This average is a partial evaluation for Competency K1. Final evaluation for K1 will be made at the end of JS2-L3-UVI.)

JS2-L2-UIV

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

REMOVING AND INSTALLING A THROTTLE BODY INJECTOR

Equipment:

Hand tools
Serviceable vehicle
Special tools as outlined in assignment sheet
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Complete AS2-L2-UIV. Following the procedure developed in item 2 of AS2-L2-UIV, remove the fuel injector. __ __ __ __

   (**CAUTION:** Fuel injected vehicles with electric fuel pumps retain high pressure in the fuel system for long periods of time after the engine is shut off. This pressure must be relieved before any fuel hoses are removed. Refer to the appropriate service manual for proper procedures before removing fuel lines.)

   (**CAUTION:** Automotive fuel is highly flammable. Do not service fuel systems in the presence of sparks or open flame. Store fuel in approved sealed containers. Clean up any fuel spill immediately.)

3. Inspect the items identified below. __ __ __ __

   a. Inspect fuel injector for evidence of dirt or other contamination.

      OK_____ NOT OK____

   b. Inspect fuel meter cover and throttle body for damage or warpage.

      OK_____ NOT OK____

   c. Inspect condition of o-rings.

      OK_____ NOT OK_____

4. Following the procedure developed in item 3 of AS2-L2-UIV, install the injector. __ __ __ __

   (NOTE: Any parts found to be defective should be repaired or replaced as directed by the instructor.)

5. Turn ignition key to run position, but do not start the engine. Inspect for fuel leakage and correct if found. Record observations. _ _ _ _

6. Connect exhaust ventilation equipment to vehicle and start engine. Check for fuel leakage and proper performance. Record results below. _ _ _ _

   (**CAUTION:** Be sure to use approved exhaust ventilation equipment when operating a vehicle in an enclosed area.)

*Average of above evaluations _ _ _ _

(*This average is a partial evaluation for Competency K6. Final evaluation for K6 will be made at the end of JS4-L2-UV.)

JS3-L2-UIV

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

REMOVING AND INSTALLING A PORT INJECTOR AND FUEL RAIL

Equipment:

Hand tools
Serviceable vehicle
Special tools as outlined in assignment sheet
Safety glasses

Procedure: Evaluation 3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Complete AS3-L2-UIV. Following the procedure developed in items 2 and 3 of AS3-L2-UIV, remove the fuel rail and injector(s). ___ ___ ___ ___

   (**CAUTION:** Fuel injected vehicles with electric fuel pumps retain high pressure in the fuel system for long periods of time after the engine is shut off. This pressure must be relieved before any fuel hoses are removed. Consult the appropriate service manual for proper procedures before removing fuel lines.)

   (**CAUTION:** Automotive fuel is highly flammable. Do not service fuel systems in the presence of sparks or open flame. Store fuel in approved, sealed containers. Clean up any fuel spill immediately.)

3. Inspect the items identified below. ___ ___ ___ ___

   a. Inspect fuel injector for evidence of dirt or other contamination.

      OK_____ NOT OK____

   b. Inspect fuel meter cover and throttle body for damage or warpage.

      OK_____ NOT OK_____

   c. Inspect condition of o-rings.

      OK_____ NOT OK______

   d. Inspect condition of wire terminals.

      OK_____ NOT OK______

4. Following the procedure developed in items 4 and 5, install the injector and fuel rail. ___ ___ ___ ___

   (NOTE: Any parts found to be defective should be repaired or replaced as directed by the instructor.)

5. Turn ignition key to run position but do not start the engine. Inspect for fuel leakage and correct if found. — — — —

6. Connect exhaust ventilation equipment to vehicle and start engine. Check for fuel leakage and proper performance. Record results below. — — — —

   (**CAUTION:** Be sure to use approved exhaust ventilation equipment when operating a vehicle in an enclosed area.)

7. Shut off engine and disconnect exhaust ventilation equipment. — — — —

   *Average of above evaluations — — — —

   (*This average is a partial evaluation for Competency K6. Final evaluation for K6 will be made at the end of JS4-L2-UV.)

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

REMOVING AND INSTALLING THE THROTTLE BODY

Equipment:

Hand tools
Serviceable vehicle
Special tools as outlined in assignment sheet
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Complete AS4-L2-UIV. Following the procedure outlined in item 2 of AS4-L2-UIV, remove the throttle body. ___ ___ ___ ___

   (**CAUTION:** Fuel injected vehicles with electric fuel pumps retain high pressure in the fuel system for long periods of time after the engine is shut off. This pressure must be relieved before any fuel hoses are removed. Consult the appropriate service manual for proper procedure before removing fuel lines.)

   (**CAUTION:** Automotive fuel is highly flammable. Do not service fuel systems in the presence of sparks or open flame. Store fuel in approved, sealed containers. Clean up any fuel spill immediately.)

3. Remove old gasket and clean mating surfaces. Inspect intake manifold bore for loose parts, foreign material, etc. that may have fallen into the manifold. Record observations. ___ ___ ___ ___

4. Following the procedure developed in item 3 of AS4-L2-UIV, install the throttle body. ___ ___ ___ ___

   (NOTE: Any parts found to be defective should be repaired or replaced as directed by the instructor.)

5. Operate accelerator and check for binding of linkage. Record observations. If binding is noted, correct before proceeding. ___ ___ ___ ___

6. Turn ignition key to run position but do not start car. Inspect for fuel leakage and correct if found. Record observations. ___ ___ ___ ___

7. Connect exhaust ventilation equipment to vehicle and start engine. Check for fuel leakage and proper performance. Record results below. — — — —

   (**CAUTION:** Be sure to use approved exhaust ventilation equipment when operating a vehicle in an enclosed area.)

8. Shut off engine and disconnect exhaust ventilation equipment. — — — —

   *Average of above evaluations — — — —

   (*This average is a partial evaluation for Competency K6. Final evaluation for K6 will be made at the end of JS4-L2-UV.)

JS5-L2-UIV

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

ADJUSTING THROTTLE BODY MINIMUM IDLE SPEED

Equipment:

Hand tools
Tachometer
Serviceable vehicle
Safety glasses

Procedure:

	Evaluation 3	 2	 1	 N
1. Wear safety glasses while doing all procedures on this job sheet.	___	___	___	___
2. Complete AS5-L2-UIV. Following the procedure developed in item 2 of AS5-L2-UIV, check and adjust the minimum idle speed. Answer the below questions.	___	___	___	___

(**CAUTION:** Be sure to use approved exhaust ventilation equipment when operating vehicle in an enclosed area.)

a. Did the minimum idle speed meet specifications?

YES_____ NO_____

b. Did idle speed meet specification after adjustment was attempted?

YES_____ NO_____

*Average of above evaluations ___ ___ ___ ___

(*This average is a partial evaluation for Competencies K5 and K7. Final evaluation for K5 will be made at the end of JS2-L2-UV. Final evaluation for K7 will be made below.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency K7 by averaging the evaluations of JS2-L1-UIII, JS3-L1-UIII, and JS5-L2-UIV. Use the spaces provided below.

	Evaluation 3	 2	 1	 N
JS2-L1-UIII	___	___	___	___
JS3-L1-UIII	___	___	___	___
JS5-L2-UIV	___	___	___	___
Final evaluation for Competency K7	___	___	___	___

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT IV: GASOLINE ENGINE ELECTRONIC FUEL INJECTION

UNIT IV TEST

PART I. FUEL INJECTION SYSTEMS

SECTION A. **Read the statements below. Place a T or an F in the blank beside each statement to indicate whether each statement is true or false.**

____ 1. The abbreviations CFI and TBI refer to the same type of fuel injection system.

____ 2. PFI fuel injection systems have one fuel injector for each cylinder.

____ 3. Nearly all new cars use fuel injection.

____ 4. Fuel injection systems produce less pollution than conventional fuel systems.

____ 5. Direct fuel injection systems are seldom used on diesel engines.

____ 6. The most popular form of fuel injection is called intake manifold injection.

____ 7. Sequential PFI affords the highest performance from a fuel injection system.

____ 8. A continuous injection system does not require the use of an ECM.

____ 9. The fuel pumps used for injection systems must move high volumes of fuel.

____ 10. Fuel injection systems usually use two fuel filters.

____ 11. Fuel pressure regulators are not used on most fuel injection systems.

____ 12. Fuel injection systems use a fuel return line just like carburetor fuel systems.

____ 13. A fuel rail is used on a TBI fuel system.

____ 14. On PFI systems, the throttle body is used only for air control.

SECTION B. **Read each of the below statements made by Technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.**

____ 15. TECHNICIAN I says that a throttle position sensor is needed for both TBI and PFI systems.

TECHNICIAN II says that an idle control solenoid is used on both TBI and PFI systems.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 16. TECHNICIAN I says that a fuel injector is nothing more than a precision electromagnetic fuel valve.

TECHNICIAN II says that all port type electronic fuel injection systems must have a signal from the ECM before they will open.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 17. TECHNICIAN I says that many late-model carburetors were much simpler than the new TBI fuel injection systems.

TECHNICIAN II says that the fuel regulator used on many TBI systems is found in the carburetor housing.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 18. TECHNICIAN I says that TBI fuel pressure regulators use engine vacuum to control the fuel line pressure.

TECHNICIAN II says that, in TBI fuel injection systems, I or R injectors are mounted above the throttle plates.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 19. TECHNICIAN I says that a throttle position sensor is a potentia meter.

TECHNICIAN II says that the idle air control (IAC) is used to maintain engine idle speed.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 20. TECHNICIAN I says that idle speed control (ISC) is maintained by a conical valve known as a pintle.

TECHNICIAN II says that, in port fuel injection systems, the fuel injectors are located in the intake manifold ports.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 21. TECHNICIAN I says that throttle body fuel injection (TBI) provides better fuel distribution than port fuel injection.

TECHNICIAN II says that a Bosh K-Jetronic Fuel Injection Systems is basically a mechanical system.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 22. TECHNICIAN I says that the idle fuel mixture can be adjusted on all fuel injection systems except the Bosch K Jetronic System.

TECHNICIAN II says that the Bosch K Jetronic uses a fuel distributor to control the fuel sent to injectors.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 23. TECHNICIAN I says that fuel injection systems offer faster engine response

TECHNICIAN II says that some fuel injection systems shut off the fuel as the vehicle decelerates.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 24. TECHNICIAN I says grouped injection systems are "fired" at the same time during every distributor rotation.

TECHNICIAN II says most fuel injection systems use a high-pressure mechanical fuel pump.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 25. TECHNICIAN I says that fuel lines and hoses used for fuel injection systems must be capable of withstanding much more pressure than hoses and lines used on carburetor-equipped engines.

TECHNICIAN II says that the fuel pressure regulator is generally found at the fuel pump.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

(NOTE: The student must obtain a minimum score of _____ on Part I of the Unit IV Test in order to receive an evaluation for Competencies K1, K5, K6, and K7.)

PART II. DIAGNOSING FUEL SYSTEMS

SECTION A. **Read the statements below. Place a T or an F in the blank beside each statement to indicate whether each statement is true or false.**

____ 26. Before performing a diagnostic procedure on a fuel injection system, a visual inspection should be made of other systems in the vehicle.

____ 27. On computer-controlled vehicles, the performance of one component is dependent on the performance of the rest of the system.

____ 28. A loose vacuum will cause the engine to run rich.

____ 29. Fuel pressure tests determine if adequate fuel is reaching the injectors.

____ 30. A test lamp can be used to check injector operation.

____ 31. The injector must be removed before it can be checked for grounds or opens.

____ 32. Injector balance tests can only be used on TBI Systems that use two injectors.

(NOTE: The student must obtain a minimum score of _____ on Part II of the Unit IV Test in order to receive an evaluation for Competency K1.)

PART III. CLEANING FUEL INJECTION SYSTEMS

SECTION A. **Read the statements below. Place a T or an F in the blank beside each statement to indicate whether each statement is true or false.**

____ 33. Fuel injectors are usually cleaned while they are still on the vehicle.

____ 34. The fuel return must be blocked during fuel injector cleaning.

____ 35. Fuel injectors should be cleaned before electrical tests are performed on the injector.

____ 36. Fuel injection cleaning is usually accomplished only after the injector is removed and disassembled.

(NOTE: The student must obtain a minimum score of _____ on Part III of the Unit IV Test in order to receive an evaluation for Competency K5.)

PART IV. REPAIRING AND REPLACING FUEL INJECTION COMPONENTS

SECTION A. **Read the statements below. Place a T or an F in the blank beside each statement to indicate whether each statement is true or false.**

____ 37. Before attempting fuel injection repairs, remove the negative ground cable and relieve the fuel pressure.

____ 38. Fuel injectors that are identical in appearance are identical in performance.

____ 39. When installing injectors. the technician should use dry lubricants on the o-rings.

____ 40. The engine must be running before the fuel system can be pressurized.

____ 41. The fuel rail is removed before the injectors on PFI systems.

____ 42. Old gaskets cannot be used when reinstalling TBI units.

____ 43. On PFI systems, forcing the fuel rail onto the injectors will straighten improperly aligned injectors.

____ 44. A special tool is generally needed to remove injectors from the intake manifold on PFI units.

____ 45. A binding throttle should be checked only after the engine is started.

(NOTE: The student must obtain a minimum score of _____ on Part IV of the Unit IV Test in order to receive an evaluation for Competency K6.)

PART V. ADJUSTING FUEL INJECTION SYSTEMS

SECTION A. **Read the statements below. Place a T or an F in the blank beside each statement to indicate whether each statement is true or false.**

____ 46. On electronic fuel injected systems, idle speed and mixture have no service adjustments.

____ 47. Minimum idle speed can be set on electronic fuel injected engines.

____ 48. If the fuel injection stop screw is not properly adjusted, the fuel injection will not stop during deceleration.

____ 49. Minimum idle speed for most fuel injected engines is 600 to 800 rpm.

____ 50. A voltmeter on the TPS is used to set minimum idle settings.

(NOTE: The student must obtain a minimum score of _____ on Part V of the Unit IV Test in order to receive an evaluation for Competency K7.)

ANSWERS TO UNIT IV TEST

1.	t
2.	t
3.	t
4.	f
5.	t
6.	t
7.	t
8.	t
9.	f
10.	t
11.	f
12.	f
13.	f
14.	t
15.	a
16.	c
17.	d
18.	b
19.	c
20.	d
21.	b
22.	b
23.	c
24.	d
25.	a
26.	t
27.	t
28.	f
29.	t
30.	t
31.	f
32.	f
33.	t
34.	t
35.	t
36.	f
37.	t
38.	f
39.	f
40.	t
41.	t
42.	t
43.	f
44.	f
45.	f
46.	t
47.	t
48.	f
49.	f
50.	f

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT V: DIESEL FUEL INJECTION

UNIT OBJECTIVE

After completing this unit, the student should be able to test, adjust, and replace diesel fuel injection components. The student will demonstrate mastery of the material by achieving a score of ______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1. I. Identify the principles of diesel fuel injection (Competencies K2, K5, and K6, Unit V Test).

II. Identify the components of the diesel fuel injection system (Competencies K2, K5, and K6, Unit V Test).

III. Identify the operating principles of the diesel fuel injection pump (Competencies K2, K5, and K6, Unit V Test).

IV. Identify the operating principles of the diesel injection nozzle (Competencies K2, K5, and K6, Unit V Test).

Lesson 2. I. Identify the procedures for servicing diesel fuel filters (Competency K2, Parts I and II of the Unit V Test).

II. Identify the procedure for bleeding the fuel system (Competency K2, Parts I and II of the Unit V Test).

III. Identify the procedures for removing and replacing the injection nozzle (Competency K5, Parts I and III of the Unit V Test).

IV. Identify the procedure for testing the injection nozzle (Competency K5, Parts I and III of the Unit V Test).

V. Identify the procedure for replacing and removing an injection pump (Competency K6, Parts I and IV of the Unit V Test).

VI. Identify the procedure for timing a diesel injection pump (Competency K6, Parts I and IV of the Unit V Test).

VII. Demonstrate the ability to:

- a. Service a diesel fuel filter (Competency K2, JS1-L2-UV).
- b. Remove and install diesel injection nozzles and lines and test nozzle performance (Competency K5, JS2-L2-UV).
- c. Remove and install a diesel injection pump (Competency K6, JS3-L2-UV).
- d. Adjust timing of a diesel injection pump (Competency K6, JS4-L2-UV).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks H045 and H051-H057.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT V: DIESEL FUEL INJECTION

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      AS1-L1-UV: Principles of Diesel Fuel Injection

  2. Lesson 2: SERVICING DIESEL FUEL INJECTION SYSTEMS

    a. Information outline

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      AS1-L2-UV: Procedure for Replacing a Diesel Fuel Filter
      AS2-L2-UV: Procedure for Removing and Installing Diesel Injection Nozzles and Lines and Testing Nozzle Performance
      AS3-L2-UV: Procedure for Removing and Installing an Injection Pump
      AS4-L2-UV: Procedure for Adjusting Diesel Injection Timing

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      JS1-L2-UV: Servicing a Diesel Fuel Filter
      JS2-L2-UV: Removing and Installing Diesel Injection Nozzles and Lines and Testing Nozzle Performance
      JS3-L2-UV: Removing and Installing an Injection Pump
      JS4-L2-UV: Adjusting Diesel Injection Timing

E. Unit test

F. Answers to unit test

REFERENCES

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Chrysler Corporation. Technical Guide, 3.7/5.2 Liter Engine Performance. 1982.

Ford Motor Company. 1987 Light Truck Shop Manual.

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General Motors Corporation. The 6.2 Liter Diesel Engine. 1988.

General Motors Corporation. Engine Performance Testing. 1987.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L1-UV before taking the Unit V Test. Students should do AS1-L2-UV in conjunction with JS1-L2-UV; AS2-L2-UV in conjunction with JS2-L2-UV; AS3-L2-UV in conjunction with JS3-L2-UV; and AS4-L2-UV in conjunction with JS4-L2-UV.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT V: DIESEL FUEL INJECTION

LESSON 1: PRINCIPLES OF DIESEL FUEL INJECTION

I. Introduction

   A. The diesel fuel injection system is quite different from the gasoline fuel injection systems discussed in the previous unit.

      1. The diesel injection system is responsible for delivering the fuel to the injection nozzles in the right quantity and at the right time.

      2. Since a diesel engine injects the fuel directly into the combustion chamber, the fuel must be delivered under high pressure. The fuel pressure is as much as 2000 psi or greater.

      3. The diesel fuel injection system must deliver the same amount of fuel to each cylinder. If fuel delivery to each cylinder is not equal, the power produced by each cylinder will not be equal. The result will be a rough-running engine and loss of power.

   B. Diesel engines use no spark plugs, ignition coil, distributor, etc. There is no electrical ignition timing. The diesel fuel system ignites the fuel by injecting it under tremendous pressure into each cylinder at the proper time.

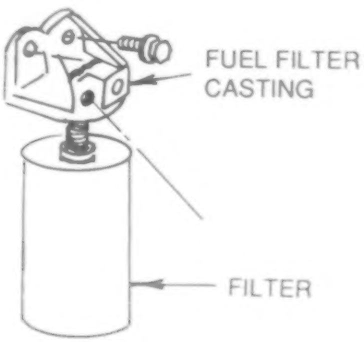
II. A diesel fuel system includes the following components: fuel tank; fuel delivery pump and lines; diesel engine fuel filter; diesel fuel heater; high-pressure diesel fuel injection pump; diesel fuel injection nozzle; high-pressure fuel lines; and a pre-chamber.

   A. The diesel fuel tank is similar to those used in gasoline-powered vehicles.

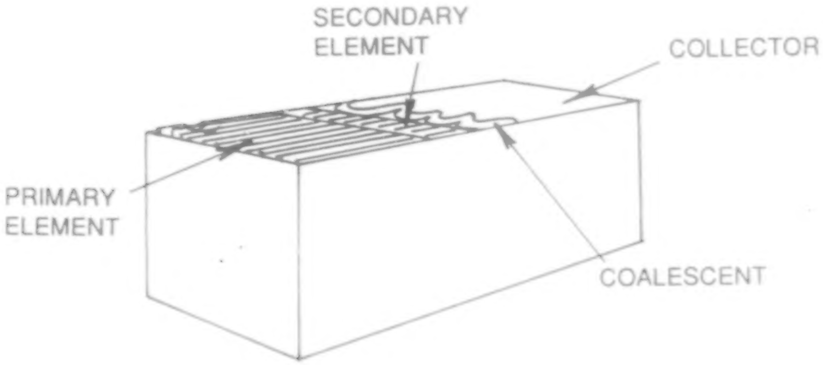
   B. The diesel fuel delivery pump and lines are also similar to those used in gasoline vehicles. Not all diesel fuel systems use a delivery pump. On some systems, an injection pump performs the entire job. A description of construction, operation, and service of the pump and lines can be found in Unit I of this section of the Engine Performance Module.

   C. Contamination from water or foreign material can be extremely harmful to the diesel fuel injection system; therefore, the filtering system is usually larger and sometimes more complex than a gasoline filtering system. A typical system may have a primary and a secondary fuel filter, or a filter and a water separator.

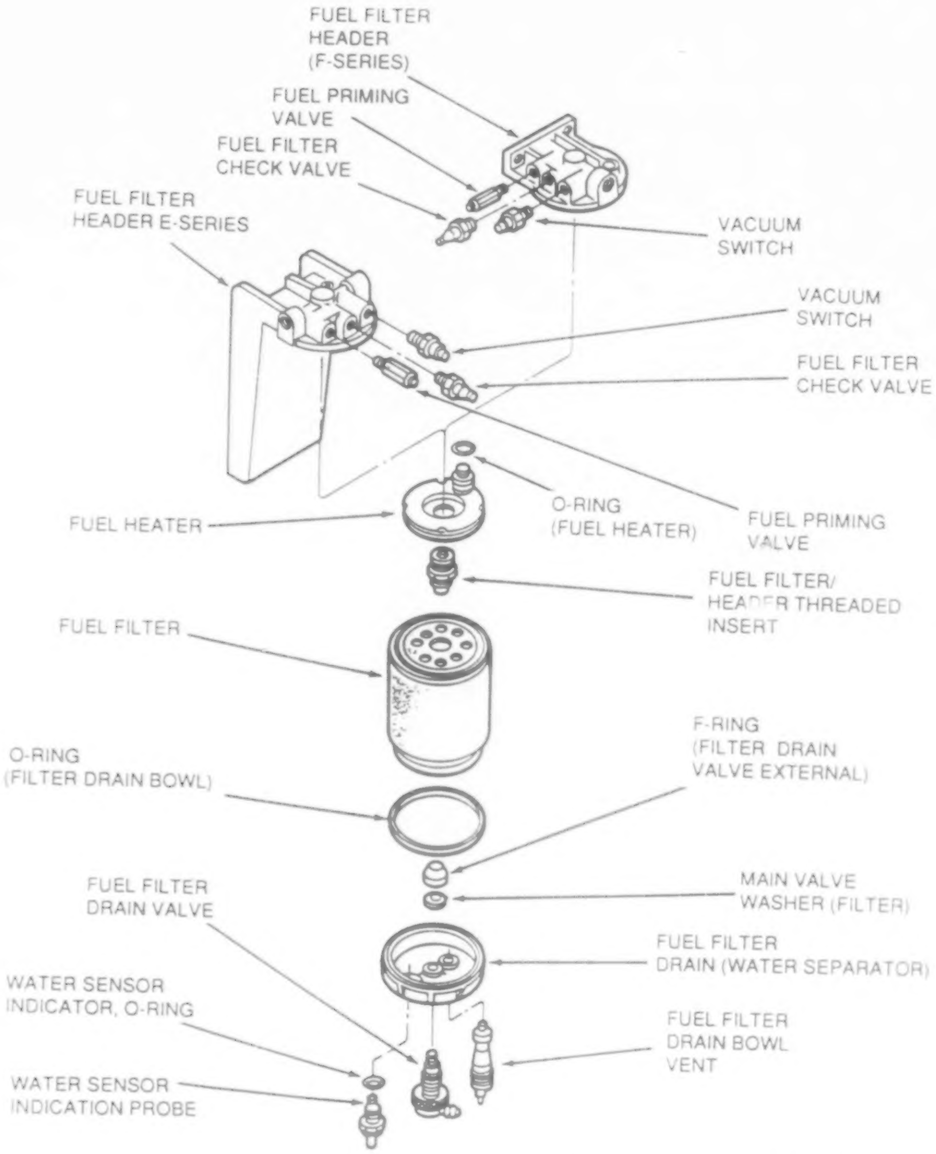
1. The filter shown in the below illustration is a spin-on filter, which is similar in appearance to an oil filter.



2. The following illustration shows a single filter, consisting of a primary filtering element made of paper, a secondary filtering element made of paper with glass particles, and a water collector at the bottom of the filter. A nylon fiberglass coalescing element is used to blend small water droplets into large ones. Small water droplets collect on this element; when the droplets become large and heavy enough, they drop into the bottom of the filter.



3. Many automobiles using diesel engines have a "water-in-fuel" sensor. This is an electronic sensor that activates a warning light on the instrument panel when an excessive amount of water is detected in the fuel system. The following illustration below shows a fuel filter with a built-in "water-in-fuel" sensor. Also included is a fuel heater. The fuel heater will be discussed later in this lesson.


FUEL FILTER HEADER (F-SERIES)
FUEL PRIMING VALVE
FUEL FILTER CHECK VALVE
FUEL FILTER HEADER E-SERIES
VACUUM SWITCH
VACUUM SWITCH
FUEL FILTER CHECK VALVE
O-RING (FUEL HEATER)
FUEL PRIMING VALVE
FUEL HEATER
FUEL FILTER/ HEADER THREADED INSERT
FUEL FILTER
F-RING (FILTER DRAIN VALVE EXTERNAL)
O-RING (FILTER DRAIN BOWL)
MAIN VALVE WASHER (FILTER)
FUEL FILTER DRAIN VALVE
FUEL FILTER DRAIN (WATER SEPARATOR)
WATER SENSOR INDICATOR, O-RING
FUEL FILTER DRAIN BOWL VENT
WATER SENSOR INDICATION PROBE

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D. Diesel fuel heater

1. Diesel fuel is sensitive to temperature. All diesel fuel contains a certain amount of heavy paraffin-like elements, which are high in energy and help improve fuel economy. But, when temperatures are less than -7 degrees C (20 degrees F), these heavy paraffin components begin turning into wax flakes. If temperatures are low enough, these flakes can build up on the fuel tank filter or the engine fuel filter and stop fuel from reaching the engine.

2. The type of fuel recommended by most manufacturers is number 2D diesel fuel. However, at temperatures below 20 degrees F, number 2D diesel fuel can form wax and clog fuel filters.

3. For operating at temperatures below -20 degrees F, most manufacturers recommend number 1D diesel fuel or a winterized blend of number 2 diesel fuel. These fuels are less likely to form wax at low temperatures. Some diesel engines are equipped with a fuel line heater to help prevent wax from building up in the fuel.

4. A typical fuel line heater consists of an electrical resistance heating element, which is wrapped around a section of fuel pipe. The heating element is wrapped in a special insulation to prevent heat loss. A thermostat on the heater turns on the heater at 20 degrees F and turns it off at 50 degrees F.

E. The high-pressure diesel fuel injection pump is the heart of the diesel fuel injection system.

1. Work performed by the diesel fuel injection pump

    a. One of the jobs of the injection pump is to meter the fuel delivered to each cylinder, thus ensuring that each cylinder receives the same amount of fuel for a given throttle position.

    b. Another responsibility of the injection pump is to raise the fuel pressure above the compression pressure in the combustion chamber before the fuel can be injected.

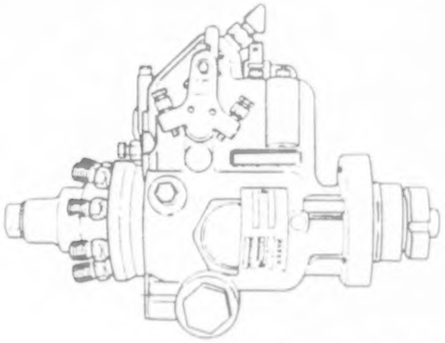
    c. Still another job of the injection pump is to deliver the fuel to the injection nozzle at the precise time for maximum engine power.

2. The injection pump is normally gear driven off the engine camshaft. Some engines use a belt (which is similar to a timing belt) to drive the injection pump.

3. Two types of fuel injection pump can be used. They are the in-line type and the distributor type.

    a. The in-line type is less common in today's cars. This type of injection pump consists of a long pump housing that encloses a separate pumping chamber for each cylinder. A camshaft inside the pump operates the individual pumps.

    b. The distributor pump is found more commonly on today's vehicles. Distributor pumps are more compact and may be more easily mounted on the engine.



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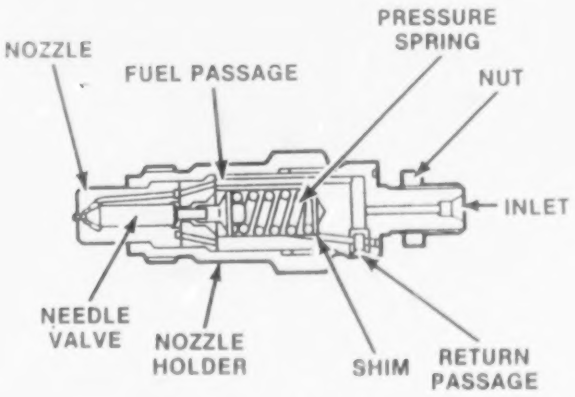
F. Diesel fuel injection nozzle

1. The fuel, which is under high pressure, is fed through high-pressure lines to each of the fuel nozzles. There is one injection nozzle for each cylinder in the engine. The proper operation of the engine depends a great deal on the fuel injection nozzles.

2. The fuel nozzle consists of a high-pressure nozzle housing, which encloses a pintle valve. The pintle valve is held on its seat by spring pressure from a calibrated spring.

3. Metered fuel from the injection pump is delivered to the nozzle body. When fuel pressure in the nozzle body is great enough to overcome spring force, the valve lifts off its seat, allowing fuel to spray into the pre-chamber. Excess fuel is bled back to the fuel tank through leak off passages.



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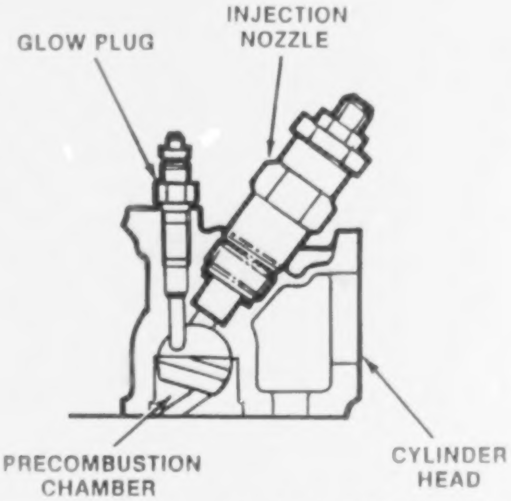
G. High pressure fuel lines are steel lines made to withstand the high pressure created by the injection pump. The lines are all equal in length in order to promote equal delivery to each nozzle.

H. Pre-chamber

1. The pre-chamber is not actually a part of the injector system but rather an internal part of the diesel engine. However, the pre-chamber is of great importance to proper ignition and combustion. Fuel is actually injected into the pre-chamber rather than directly into the combustion chamber.

2. As fuel is injected into the pre-chamber, it mixes with swirling air, allowing for more complete combustion through better vaporization. (The better vaporization results from the mixing of air and fuel.) An opening connects the pre-chamber with the main combustion chamber.



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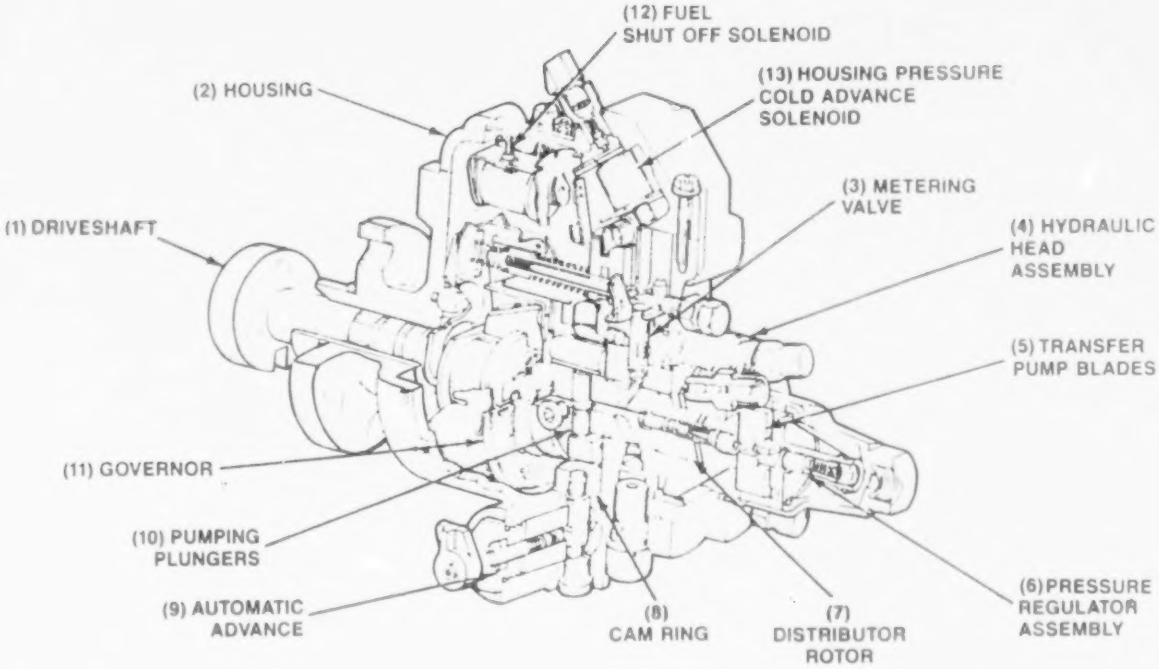
III. Diesel fuel injection pump operation

A. Main components of the fuel injection pump

1. Drive shaft
2. Housing
3. Metering valve
4. Hydraulic head assembly
5. Transfer pump
6. Pressure regulator assembly
7. Distributor rotor
8. Cam ring
9. Automatic advance
10. Pumping plungers
11. Governor


(12) FUEL SHUT OFF SOLENOID
(13) HOUSING PRESSURE COLD ADVANCE SOLENOID
(2) HOUSING
(3) METERING VALVE
(1) DRIVESHAFT
(4) HYDRAULIC HEAD ASSEMBLY
(5) TRANSFER PUMP BLADES
(11) GOVERNOR
(10) PUMPING PLUNGERS
(6) PRESSURE REGULATOR ASSEMBLY
(9) AUTOMATIC ADVANCE
(8) CAM RING
(7) DISTRIBUTOR ROTOR

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12. The main rotating components identified above are the drive shaft, the transfer pump blades, the distributor rotor, and the governor.

    a. The drive shaft engages the distributor rotor in the hydraulic head.

    b. The drive end of the pump rotor incorporates two pumping plungers.

    c. The plungers are simultaneously actuated toward each other by an internal cam ring through rollers and shoes, which are carried in slots at the drive end of the rotor.

    d. The number of cam lobes normally equals the number of engine cylinders.

13. Located on the top of the injection pump housing are two electrical connections.

    a. The front connection controls the fuel shut-off solenoid, which is wired directly to the ignition switch. This shuts off the fuel supply when the ignition switch is turned off.

    b. The rear connection controls the housing pressure cold advance solenoid, which is wired to a coolant temperature switch. This switch turns off current to the solenoid when the coolant temperature reaches 112 degrees F. This cold advance solenoid reduces any white smoke that the engine might produce while cold.

B. Operating principles of a diesel fuel injection pump

1. Fuel is pushed into the injector pump inlet through the inlet filter screen by the vane type fuel transfer pump.

2. Some fuel is bypassed through the pressure regulator assembly to the suction side.

3. Fuel under transfer pump pressure flows through the center of the transfer pump rotor, past the transfer pump pressure port and the rotor retainers into a circular groove on the rotor.

4. Fuel then flows through a connecting passage in the head to the automatic advance and up through a radial passage to the metering valve.

5. The radial position of the metering valve, controlled by the governor, regulates fuel flow into the radial charging passage, which incorporates the head charging ports.

6. As the rotor revolves, the two rotor inlet passages register with the charging ports in the hydraulic head, allowing fuel to flow into the pumping chamber.

7. With further rotation, the inlet passages move out of registry and the discharge port of the rotor registers with one of the head outlets.

8. While the discharge port is opened, the rollers contact the cam lobes, forcing the plungers together. Fuel trapped between the plungers is then pressurized and delivered by the nozzle to the combustion chamber.

9. Self lubrication of the pump is a built-in feature of the design for this injection pump. As fuel at transfer pump pressure reaches the charging ports, slots on the rotor shank allow fuel and any entrapped air to flow into the pump housing cavity.

    a. In addition, an air vent passage in the hydraulic head connects the outlet side of the transfer pump with the pump housing.

    b. This allows air and some of the fuel to be bled back to the tank via the return line.

    c. The bypassed fuel fills the housing, lubricates the internal components, and cools and carries off any small air bubbles. The pump operates with the housing completely full of fuel. There are no dead air spaces within the pump.

    (NOTE: Special equipment and facilities are required for injection pump rebuilding. Do not attempt to rebuild the pump in a normal shop situation.)

IV. Injection nozzle operation

A. The job of the injection nozzle is to direct a metered amount of fuel, under high pressure, from the injection pump to the engine combustion chamber. The injection nozzle assembly consists of two principal sub-assemblies--the nozzle and the nozzle holder.

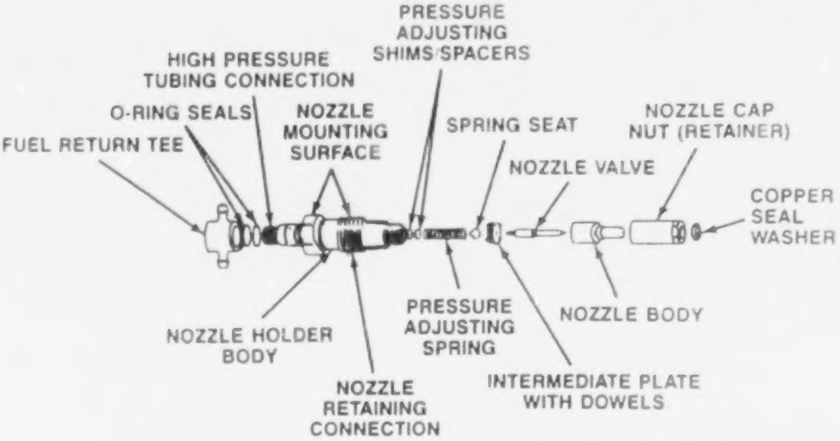
1. The nozzle holder is used to hold the nozzle in its correct position in the cylinder head and to provide channels for conducting diesel fuel to the nozzle.

2. The holder also contains the spring retainer (intermediate plate) spring, and shims for adjusting the opening pressure of the nozzle valve.

3. The lower end of the holder has an accurately ground and lapped surface. This surface makes a leakproof and pressure tight seal with the corresponding lapped surface at the upper end of the spring retainer (intermediate plate).

4. The intermediate plate mates with the lapped surface of the upper end of the nozzle.

5. The nozzle and intermediate plate are held in alignment by dowel pins and are secured to the nozzle holder by the nozzle retainer nut.


PRESSURE ADJUSTING SHIMS/SPACERS
HIGH PRESSURE TUBING CONNECTION
O-RING SEALS
NOZZLE MOUNTING SURFACE
SPRING SEAT
NOZZLE CAP NUT (RETAINER)
FUEL RETURN TEE
NOZZLE VALVE
COPPER SEAL WASHER
PRESSURE ADJUSTING SPRING
NOZZLE BODY
NOZZLE HOLDER BODY
INTERMEDIATE PLATE WITH DOWELS
NOZZLE RETAINING CONNECTION

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B. The nozzle body and the nozzle valve are lapped to form an extremely close-fitting matched set. Body and valve cannot be exchanged singly and must be replaced as an assembly. The spray hole is sized to provide a spray pattern of finely atomized fuel to produce the most efficient combustion and engine performance.

C. Operation of the injection nozzle

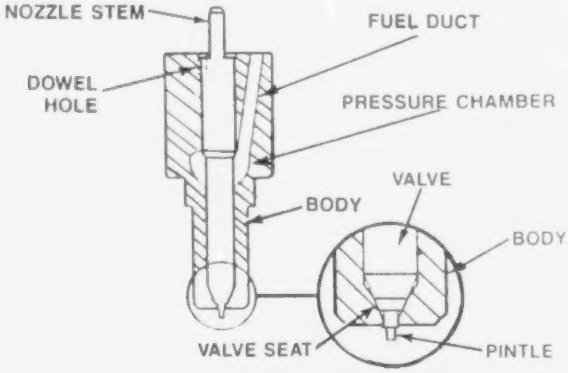
1. The metered quantity of fuel from the injection pump enters the nozzle holder through the inlet fitting, and passes through connection ducts to the pressure chamber, just above the nozzle valve seat.

2. At the instant the pressure of the fuel acting on the valve exceeds a predetermined spring load (usually 1700 to 2000 psi), it lifts the valve from its seat and fuel flows from the nozzle until delivery from the injection pump ceases.

3. Next, a positive cut-off of fuel occurs as the valve is seated by the nozzle spring.

    a. A certain amount of fuel seepage between lapped surfaces of the nozzle valve and body is necessary for lubrication.

    b. This leakage fuel accumulates in the spring cavity and drains through to the leak-off provided for this purpose.


NOZZLE STEM
FUEL DUCT
DOWEL HOLE
PRESSURE CHAMBER
VALVE
BODY
BODY
VALVE SEAT
PINTLE

EP/FS 215

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MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PRINCIPLES OF DIESEL FUEL INJECTION

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. What can happen to diesel fuel in cold temperatures?

2. How much pressure is usually required to lift a diesel injection nozzle pintle valve off its seat?

3. List two types of diesel injection pumps.

4. Inside what component does a swirl effect thoroughly mix diesel fuel with incoming air?

5. What component delivers the fuel under high pressure to the injection nozzles at precisely the right time?

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PRINCIPLES OF DIESEL FUEL INJECTION

(ANSWER SHEET)

1. Wax forms in the fuel.
2. Between 1700 and 2000 psi
3. In-line and distributor
4. Pre-chamber
5. The injection pump

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT V: DIESEL FUEL INJECTION

LESSON 2: SERVICING DIESEL FUEL INJECTION SYSTEMS

I. Servicing diesel fuel filters

(NOTE: It is very important to follow the manufacturer's recommendations for servicing diesel fuel filters. Dirt and water contamination can be extremely detrimental to diesel injection pumps and nozzles.)

A. Procedure for replacing a spin-on diesel fuel filter

1. Clean dirt and debris from around the filter before removal.

2. Place a drain pan under the filter to catch spillage. If no drain pan is available, use an absorbent towel.

3. Using an oil filter wrench, remove the filter from the filter adaptor.

4. Clean gasket surface, install new filter, and tighten 2/3 of a turn after filter gasket contacts the adaptor base.

5. After ensuring the area is clean, remove the plug from the filter adaptor and fill the fuel filter with clean fuel to prevent excess air from entering the system.

   (NOTE: If the adaptor is not equipped with a fill plug, fill the filter with clean fuel before installing the filter.)

6. Purge air from system.

   (NOTE: Air trapped in the system should be purged before starting the engine. Trapped air will cause the engine to run rough and produce white exhaust smoke.)

   a. Disconnect the fuel cut-off solenoid wire from the injection pump to prevent the engine from starting.

   b. Open bleeder valve on filter adaptor and crank engine (for 10 seconds maximum) until a solid stream of fuel is discharged (no air bubbles), then close bleeder.

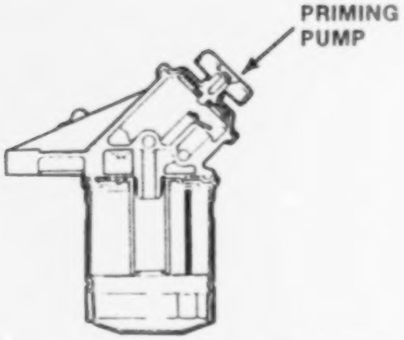
   c. If a solid stream of fuel is not flowing after 10 seconds, wait 15 seconds for the starting motor to cool. Next, crank the engine again (for a maximum of 10 seconds) until a solid stream of fuel flows from the bleeder; then, close the bleeder screw.

      (NOTE: If the vehicle is not equipped with a bleeder screw, loosen the filter outlet line and crank the engine [for 10 seconds maximum] until a solid stream of fuel flows from the fitting; then, reinstall fitting.)

   d. Remove absorbent towel, reconnect wire at injection pump, and start engine.

e. Check system for fuel leaks while engine is idling. Allow engine to idle for several minutes. (Many newer diesel fuel systems are designed to purge themselves of air as the engine runs.)

(NOTE: Some vehicles are equipped with a priming pump that can be used to bleed air from the fuel system. To use the priming pump, open the bleeder screw and operate pump until a solid stream of fuel flows from the bleeder.)



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B. Replacing the box filter

1. Procedure for removing the box filter

   a. With the engine off, place an absorbent towel under the fuel filter.

   b. Unstrap the lower bail first to relieve fuel pressure in the filter.

   c. Unstrap the upper bail and remove the filter.

2. Procedure for installing the box filter

   a. Ensure that both filter mounting plate fittings are free of dirt.

   b. Install the new filter and snap on the upper bail clamp only.

3. Procedure for purging air from system

   a. Disconnect wire from injection pump fuel cut off solenoid.

   b. Crank engine (for 10 seconds maximum) until fuel is observed at the lower fuel fitting.

      (NOTE: If fuel is not observed after 10 seconds, wait 15 seconds and repeat step b.)

   c. When fuel is observed at the lower fuel fitting, connect the lower bail clamp.

   d. Reconnect the fuel cut-off solenoid wire. If air cleaner was removed, replace it before starting. Remove absorbent towel.

   e. Start engine and allow it to idle for several minutes. Check for fuel leakage.

II. Bleeding the fuel system

A. Air in the fuel system will cause the engine to run poorly. The system should be purged of air after the system has been serviced.

B. Bleeding air from the system is accomplished by cracking (loosening a slight amount) the injector nozzle lines one at a time while cranking or running the engine. The line is tightened when a solid stream of fuel flows with no air.

C. Bleeder valves are also provided on some injection pumps and filters. The valves can be opened to bleed air from the system.

D. Some systems are designed to automatically bleed themselves during operation. Consult the appropriate service manual for detailed instructions on purging air from the fuel system.

III. Procedure for removing and replacing the injection nozzle

A. Remove fuel injection lines

1. Clean area around nozzle to prevent the entry of foreign objects into the engine.

2. Use a backup wrench on the injection nozzle upper hex to prevent loosening the injector nut and causing a fuel leak. Remove fuel delivery lines.

3. Remove fuel return lines.

4. Cap all open lines, nozzles, and pump to prevent contamination.

B. Remove injection nozzles using the proper socket.

C. Install injection nozzles.

1. There is a copper sealing washer on the end of each injector. Replace the washer before installing the injector to prevent compression leakage.

2. Tighten each nozzle to the manufacturer's specified torque.

D. Replace fuel delivery and return lines.

E. Bleed air from system as required by the manufacturer.

F. Run engine and inspect for leaks.

IV. Testing the injection nozzle

A. Problems with injection nozzles are usually indicated by one or more of the following symptoms.

1. Smokey exhaust (black)

2. Loss of power

3. Misfiring

4. Increased fuel consumption

5. Combustion knock

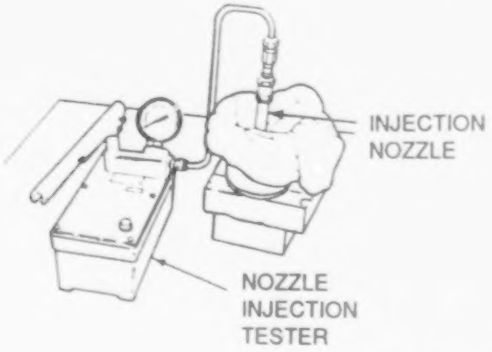
6. Engine overheating

B. When faulty nozzle operation is suspected of causing an engine to misfire or puff black smoke, a simple test can be made to determine which cylinder(s) is causing the problem.

1. Run the engine at the rpm that makes the problem most pronounced.
2. Momentarily loosen the high pressure fuel inlet line connection on one nozzle assembly one half to one turn. Then, tighten the connection to specification.
3. Check each cylinder in the same manner.
4. If loosening a particular connection does not stop the misfiring but does stop the puffing black smoke, then the nozzle served by the connection should be tested.
5. After removing the nozzle(s) from the engine, the injection nozzle test should be performed. This test will provide valuable information regarding the condition of the nozzle(s). A clean workbench, clean washing fluid containers, clean tools and clean hands are all essential to producing satisfactory results.

C. Procedure for nozzle test

(NOTE: A nozzle test stand is needed to perform this test.)



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(**CAUTION:** Always wear approved safety glasses when operating the tester. Keep away from sparks and open flames to prevent ignition of the tester fluid.)

1. Prepare stand for testing nozzles.
   a. Fill test stand reservoir with clean calibrated fluid.

      (NOTE: Use only liquid fluid approved for use in the tester. See operating instructions for fluid type. Do not use diesel fuel. Diesel fuel is unstable with respect to corrosion inhibition and may cause skin problems.)

   b. Open tester valve slightly and operate tester handle to expel air from the tester and outlet pipe.
   c. Operate tester until solid fluid (without air bubbles) flows from the end of the outlet pipe. Close tester valve.
2. Connect injection nozzle to test stand.

   a. Tighten connector nut securely with an end wrench. Be careful not to cross thread the fitting.

   b. The nozzle adaptor, which is supplied with the tester, has right-hand thread to the nozzle assembly and left-hand thread to the tester piping.

3. Bleed all air from the nozzle. Open stand valve and give tester handle several quick strokes to bleed air from the injection nozzle.

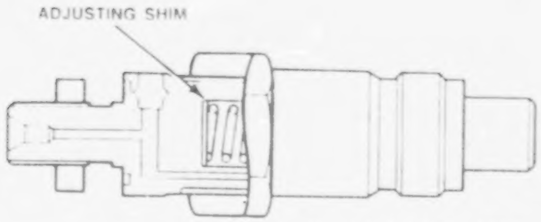
   (CAUTION: When a nozzle is being tested or is in operation, keep hands and other parts of the body away from the spraying nozzle. The liquid spray leaves the nozzle tip with sufficient force to penetrate the skin, causing serious injury. The nozzle tip should be enclosed in a transparent receptacle, if available.)

4. Check nozzle opening pressure.

   a. Open gauge valve and build up line pressure slowly by depressing the handle until the nozzle opens (sprays fuel).

   b. Observe gauge to determine pressure at which the nozzle opens; then repeat operation until accurate opening pressure is established. See appropriate service manual for opening pressure specification.

   c. If opening pressure is not within specification, adjust by replacing the adjusting shim with a shim of the correct thickness.



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5. Test for tip leakage.

   a. Wipe nozzle tip dry.

   (NOTE: Do not wipe tip with fingers. Doing so will tend to draw the fuel in the sac hole through the orifice and give false indication of a leak.)

   b. Operate test pump to maintain pressure at 200 psi below the opening pressure of the nozzle.

   c. The nozzle tip should remain dry without an accumulation of fuel droplets at the spray holes. A slight wetting after about 5 seconds is permissible if no droplets are formed.

6. Check for fuel leak-off.

   a. Operate test pump in quick strokes and observe flow of fluid from fuel return ports of nozzle.

   b. A very slight leak-off, one or two drops per stroke, is normal. If fluid squirts from the fuel return port when test pump is operated, the nozzle is faulty and must be replaced.

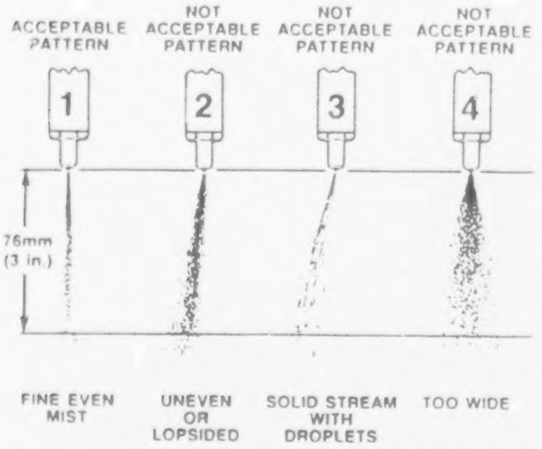
7. Check spray pattern

   a. Operate test pump in smooth, even strokes and observe the pattern of fluid spraying from the nozzle tip.

   b. Only the first 3 inches (76 mm) of spray is important.

   c. The spray should be finely atomized in an even, straight pattern. The nozzle is defective if the spray pattern is lopsided (not concentric with the nozzle axis) or uneven, or if fuel comes out in droplets or in a solid stream.

   d. If nozzle fai[illegible]pray pattern test, clean or replace the nozzle according to the manu[illegible]er's instructions; then, repeat the spray pattern test.


ACCEPTABLE PATTERN
NOT ACCEPTABLE PATTERN
NOT ACCEPTABLE PATTERN
NOT ACCEPTABLE PATTERN
1
2
3
4
76mm (3 in.)
FINE EVEN MIST
UNEVEN OR LOPSIDED
SOLID STREAM WITH DROPLETS
TOO WIDE

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8. Chatter test

   (NOTE: Chatter is a noise normally made by the nozzle during operation. Some manufacturers recognize chatter as a test criteria while others do not. Consult manufacturer's recommendations when testing for chatter.)

   a. Close shutoff valve lever at pressure gauge.

   b. Depress lever of test stand slowly, noting whether chatter noises can be heard.

   c. If no chatter is heard, increase the speed of lever movement until it reaches a point where the nozzle chatters.

   d. The chatter indicates that the nozzle seat, guide, as well as the pintle, have no mechanical defects.

e. Replace nozzles that do not chatter.

(NOTE: When testing for chatter, it should be noted that the sound [chatter] for new or used nozzles may vary. On some used nozzles, chatter is difficult to detect during slow actuation of the hand test stand lever. As long as there is chatter, the nozzle is acceptable.)

9. Nozzle cleaning

(NOTE: Most nozzles can be cleaned. The following is an example of disassembling and cleaning procedures for one type of nozzle. Consult the appropriate service manual when working with a specific vehicle.)

a. Disassemble the fuel injectors, being careful to keep the pieces of each injector separate. The pieces of each injector are closely matched.

b. Clean the injector components as directed by the manufacturer.

c. Retest injectors that have been cleaned before reinstalling them.

V. Replacing and removing an injection pump

(NOTE: The procedure for replacing and removing an injection pump will vary greatly, depending on the type of engine and type of pump to be serviced. Consult the appropriate service manual when working with a specific vehicle.)

A. Procedure for removing an injection pump

1. Remove the air cleaner assembly.

2. Remove the crank case ventilation filters and pipes from the valve covers and air crossover.

3. To prevent objects from falling into the intake, remove the air crossover and install screened covers on the intake manifold.

4. Disconnect the throttle rod and throttle return spring. Remove the throttle bellcrank.

5. Remove the throttle and throttle valve/detent cables from the intake manifold brackets. Position the cables away from the engine.

6. Remove the fuel filter and the line leading from the fuel filter to the injection pump.

7. Disconnect the fuel return line from the injection pump.

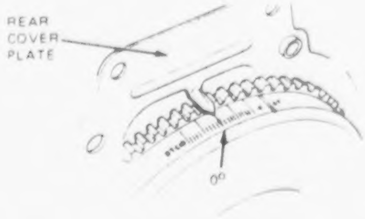
8. Using two wrenches, disconnect injection pump lines at the nozzles.

9. Remove the three nuts retaining the injection pump and remove the pump. Discard pump to adaptor o-ring.

10. Cap all open lines and nozzles.

B. Procedure for installing injection pump

1. Position the engine's number 1 cylinder to firing position by aligning the mark on the balancer with the zero mark on the indicator located on the front of the engine.



2. The injection pump driven gear index is offset to the right when the number 1 cylinder is set at TDC.

3. Remove protective caps; then, line up the offset tang on the pump drive shaft with the pump driven gear. Install a new pump to adaptor o-ring; then install the pump, full seating the pump by hand.

4. Connect injection lines to the nozzles using two wrenches. Tighten line nuts to specified torque.

5. Connect all other parts in reverse order of disassembly.

   a. Do not install air crossover at this time.

   b. Bleed fuel lines as outlined earlier in this lesson.

6. Start engine and check for leaks.

7. Check and adjust pump timing as necessary. For this procedure, see manufacturer's instructions.

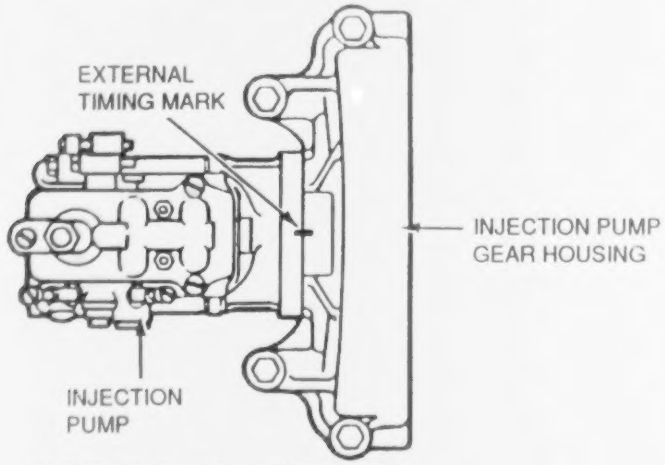
8. Adjust idle speed as necessary. See manufacturer's instructions for setting idle speed.

9. Shut off engine and complete reassembly of system.

VI. Timing a diesel injection pump

A. Static timing is generally performed by loosening the bolts holding the injection pump to the engine and, then, rotating the pump until the pump body line is aligned with the pump adaptor line.

(NOTE: Never run the engine while the fuel-injection pump is loose. Engine and/or pump damage will result.)


EXTERNAL TIMING MARK
INJECTION PUMP GEAR HOUSING
INJECTION PUMP

INJECTION TIMING - STATIC CHECK -

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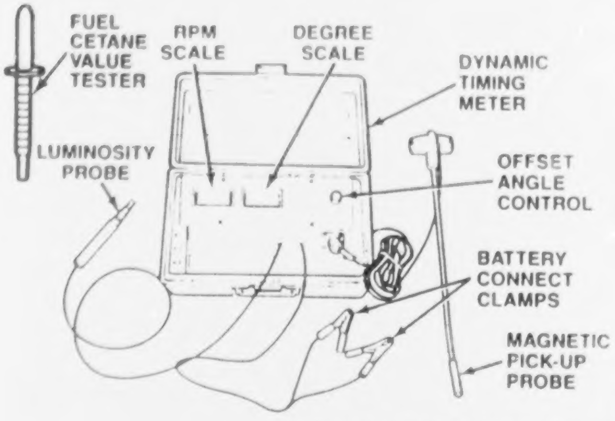
B. Dynamic timing involves checking timing with the engine running. A special timing meter is used for this purpose.


FUEL CETANE VALUE TESTER
RPM SCALE
DEGREE SCALE
DYNAMIC TIMING METER
LUMINOSITY PROBE
OFFSET ANGLE CONTROL
BATTERY CONNECT CLAMPS
MAGNETIC PICK-UP PROBE

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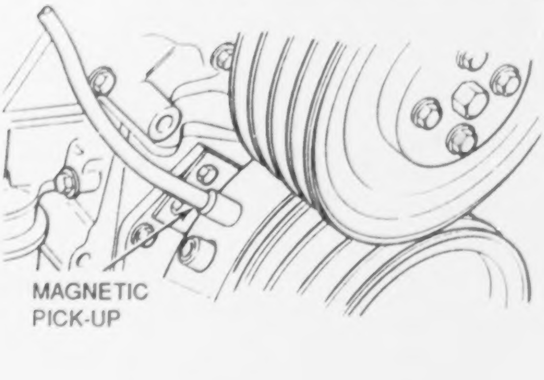
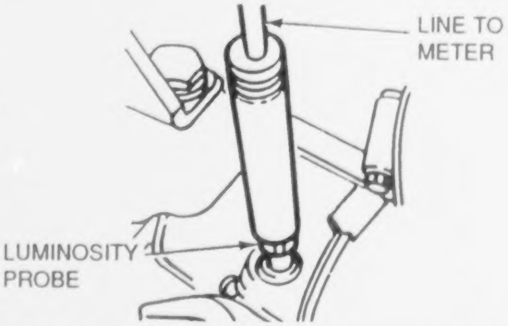
1. A magnetic pickup on the meter is placed in a holder at the harmonic balancer. The meter provides information on engine speed and position.


MAGNETIC PICK-UP


LINE TO METER
LUMINOSITY PROBE

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2. A luminosity probe is installed in the combustion chamber to sense combustion. (A luminosity probe is a light-sensitive device that is installed in the number 1 cylinder glow plug hole. The probe detects the beginning of combustion.)

3. Information from the light-sensitive probe and from the magnetic pickup are fed into a timing meter and tachometer. Timing and engine rpm are then given in a readout on the meter.

4. Actual timing readout is affected by the cetane value of the fuel and the altitude.

    a. Cetane value or rating is a quality rating for diesel fuel. Cetane value is similar to the octane rating given to gasoline.

    b. Basically, the higher the cetane rating, the more easily the fuel will ignite.

    c. A conversion chart can be used to compensate for cetane and altitude.

C. Procedure for performing dynamic timing

1. Run engine until it reaches normal operating temperature.

2. Stop engine and install a dynamic timing meter.

    a. Place magnetic probe in holder at harmonic balancer.

    b. Remove number one glow plug and install luminosity probe in glow plug hole. Install photocell over probe.

3. Connect meter to battery.

4. Start engine, operate engine at specified rpm, and observe timing meter. Compare to specifications. Use a conversion chart to compensate for cetane value and altitude.

5. If timing is incorrect, turn engine off, loosen and rotate pump as directed by the manufacturer's instructions, and then retighten.

6. Start engine and recheck timing. Repeat above steps, if necessary.

7. Shut off engine, disconnect equipment, and replace glow plug.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR REPLACING A DIESEL FUEL FILTER

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, engine size, and year of the vehicle to be serviced.
2. Develop a written procedure for replacing a diesel fuel filter and for bleeding air from the fuel system after filter replacement.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR REMOVING AND INSTALLING DIESEL INJECTION NOZZLES AND LINES AND TESTING NOZZLE PERFORMANCE

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, engine size, and year of the vehicle to be serviced.
2. Develop a written procedure for removing the fuel injectors and lines.
3. Develop a written procedure for testing injection nozzle condition as indicated in JS2-L2-UV. Include nozzle opening pressure specifications.
4. Develop a written procedure for installation of the injection nozzles and lines. Include instructions for bleeding air from the injection system.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR REMOVING AND INSTALLING AN INJECTION PUMP

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, engine size, and year of the vehicle to be serviced.
2. Develop a written procedure for removing the diesel injection pump.
3. Develop a written procedure for installing the injection pump and correctly setting static timing.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR ADJUSTING DIESEL INJECTION TIMING

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, engine size, and year of the vehicle to be serviced.
2. Develop a written procedure for checking and adjusting static timing on the engine.
3. Develop a written procedure for checking and adjusting dynamic timing on the engine. Also determine and record dynamic timing specification and the engine speed at which the timing should be checked.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

SERVICING A DIESEL FUEL FILTER

Equipment:

Hand tools
Serviceable vehicle
Special tools as outlined in assignment sheet
Safety glasses

Procedure:

	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	— — — —
2. Complete AS1-L2-UV. Following the procedure developed in item 2 of AS1-L2-UV, replace the diesel fuel filter and bleed air from the injection system.	— — — —
(**CAUTION:** Automotive fuel is highly flammable. Do not service fuel systems in the presence of sparks or open flame. Store fuel in approved sealed containers. Clean up any spilled fuel immediately.)	
3. Connect exhaust ventilation equipment, start engine, and allow it to idle. Inspect for fuel leakage and correct immediately if found. Allow vehicle to idle for a few minutes to purge any remaining air. Record observations.	— — — —
*Average of above evaluations	— — — —

(*This average is a partial evaluation for Competency K2. Final evaluation for K2 will be made at the end of this job sheet.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency K2 by averaging the evaluations of JS1-L2-UI, JS2-L2-UI, JS3-L2-UI, JS4-L2-UI, JS5-L2-UI, and JS1-L2-UV. Use the spaces below.

	Evaluation			
	3	2	1	N
JS1-L2-UI	___	___	___	___
JS2-L2-UI	___	___	___	___
JS3-L2-UI	___	___	___	___
JS4-L2-UI	___	___	___	___
JS5-L2-UI	___	___	___	___
JS1-L2-UV	___	___	___	___
Final evaluation for Competency K2	___	___	___	___

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

REMOVING AND INSTALLING DIESEL INJECTION NOZZLES AND LINES AND TESTING NOZZLE PERFORMANCE

Equipment:

Hand tools
Serviceable vehicle
Injection nozzle tester
Special tools as outlined in assignment sheet
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Complete AS2-L2-UV. Following the procedure developed in item 2 of AS2-L2-UV, remove the fuel injection lines and injectors. Keep injectors in order, according to the cylinder from which they are removed. ___ ___ ___ ___

   (**CAUTION:** Automotive fuel is highly flammable. Do not service fuel systems in the presence of sparks or open flame. Store fuel in approved, sealed containers. Clean up any fuel spill immediately.)

3. Following the procedure outlined in item 3 of AS2-L2-UV, test the condition of each fuel injector. Record the results of the tests in the spaces below. ___ ___ ___ ___

   a. Nozzle opening pressure (Compare pressure to specification determined in AS2-L2-UV.)

      Cylinder 1 OK_____ NOT OK_____

      Cylinder 2 OK_____ NOT OK_____

      Cylinder 3 OK_____ NOT OK_____

      Cylinder 4 OK_____ NOT OK_____

      Cylinder 5 OK_____ NOT OK_____

      Cylinder 6 OK_____ NOT OK_____

      Cylinder 7 OK_____ NOT OK_____

      Cylinder 8 OK_____ NOT OK_____

b. Tip leakage

Cylinder 1 OK____ NOT OK____
Cylinder 2 OK____ NOT OK____
Cylinder 3 OK____ NOT OK____
Cylinder 4 OK____ NOT OK____
Cylinder 5 OK____ NOT OK____
Cylinder 6 OK____ NOT OK____
Cylinder 7 OK____ NOT OK____
Cylinder 8 OK____ NOT OK____

c. Fuel leak-off

Cylinder 1 OK____ NOT OK____
Cylinder 2 OK____ NOT OK____
Cylinder 3 OK____ NOT OK____
Cylinder 4 OK____ NOT OK____
Cylinder 5 OK____ NOT OK____
Cylinder 6 OK____ NOT OK____
Cylinder 7 OK____ NOT OK____
Cylinder 8 OK____ NOT OK____

d. Spray pattern

Cylinder 1 OK____ NOT OK____
Cylinder 2 OK____ NOT OK____
Cylinder 3 OK____ NOT OK____
Cylinder 4 OK____ NOT OK____
Cylinder 5 OK____ NOT OK____
Cylinder 6 OK____ NOT OK____
Cylinder 7 OK____ NOT OK____
Cylinder 8 OK____ NOT OK____

e. Chatter

(NOTE: Perform this test only if recommended by the manufacturer.)

Cylinder 1 OK_____ NOT OK_____

Cylinder 2 OK_____ NOT OK_____

Cylinder 3 OK_____ NOT OK_____

Cylinder 4 OK_____ NOT OK_____

Cylinder 5 OK_____ NOT OK_____

Cylinder 6 OK_____ NOT OK_____

Cylinder 7 OK_____ NOT OK_____

Cylinder 8 OK_____ NOT OK_____

4. Following the procedure developed in item 4 of AS2-L2-UV, reinstall the nozzles and lines and bleed air from the system. — — — —

(NOTE: As directed by the instructor, replace any injectors that fail to meet the manufacturer's standards. If injectors require cleaning, clean them according to manufacturer's instructions.)

(**CAUTION:** Be sure to use approved exhaust ventilation equipment when operating a vehicle in an enclosed area.)

*Average of above evaluations — — — —

(*This average is a partial evaluation for Competency K5. Final evaluation for K5 will be made at the end of this job sheet.)

FINAL EVALUATION INSTRUCTIONS

i. Determine the student's final evaluation for Competency K5 by averaging the evaluations of JS5-L2-UIV and JS2-L2-UV. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS5-L2-UIV	___	___	___	___
JS2-L2-UV	___	___	___	___
Final evaluation for Competency K5	___	___	___	___

JS3-L2-UV

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

REMOVING AND INSTALLING AN INJECTION PUMP

Equipment:

Hand tools
Serviceable vehicle
Special tools as outlined in assignment sheet
Safety glasses

Procedure:	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2. Complete AS3-L2-UV. Following the procedure developed in item 2 of AS3-L2-UV, remove the injection pump from the vehicle.	__ __ __ __
(**CAUTION:** Automotive fuel is highly flammable. Do not service fuel systems in the presence of sparks or open flame. Store fuel in approved sealed containers. Clean up any spilled fuel immediately.)	
(NOTE: Cap all open lines and nozzles.)	
3. Following the procedure developed in AS3-L2-UV, install the injection pump and correctly set static timing.	__ __ __ __
(NOTE: Make certain that timing is correct by aligning the marks as outlined in the appropriate service manual.)	
(NOTE: Bleed injection pump and lines as instructed by the manufacturer.)	
4. Connect exhaust ventilation equipment, start engine, and check for fuel leakage. Correct immediately if leakage is noted. Observe for proper engine operation. Shut off engine and disconnect exhaust equipment.	__ __ __ __
*Average of above evaluations	__ __ __ __

(*This average is a partial evaluation for Competency K6. Final evaluation for K6 will be made at the end of JS4-L2-UV.)

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

ADJUSTING DIESEL INJECTION TIMING

Equipment:

Hand tools
Diesel timing meter/tachometer
Serviceable vehicle
Special tools as outlined in assignment sheet
Safety glasses

Procedure:

	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2. Complete AS4-L2-UV. Following the procedure developed in item 2 of AS4-L2-UV, set the static timing.	__ __ __ __

(**CAUTION:** Do not attempt to adjust the injection pump with the engine running. Running the engine with the pump loose will damage the engine and/or pump.)

3. Following the procedure developed in AS4-L2-UV, check and adjust the dynamic timing. Be suer to follow manufacturer's specifications.	__ __ __ __

(**CAUTION:** Be sure to use approved exhaust ventilation equipment when operating a vehicle in an enclosed area.)

(**CAUTION:** Do not loosen the injection pump with the engine running. Shut engine off to adjust injection pump timing.)

*Average of above evaluations __ __ __ __

(*This average is a partial evaluation for Competency K6. Final evaluation for K6 will be made at the end of this job sheet.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency K6 by averaging the evaluations of JS2-L2-UIII, JS3-L2-UIII, JS2-L2-UIV, JS3-L2-UIV, JS4-L2-UIV, JS3-L2-UV, and JS4-L2-UV. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS2-L2-UIII				
JS3-L2-UIII				
JS2-L2-UIV				
JS3-L2-UIV				
JS4-L2-UIV				
JS3-L2-UV				
JS4-L2-UV				
Final evaluation for Competency K6				

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT V: DIESEL FUEL INJECTION

UNIT V TEST

PART I. DIESEL FUEL INJECTION SYSTEMS

SECTION A. **Read the statements below. Place a** T or F **in the blank beside each statement to indicate whether it is true or false.**

____ 1. Diesel fuel pressures will sometimes exceed 2,000 psi.

____ 2. Not all diesel engines use a fuel pump.

____ 3. Diesel engines use complex fuel filtering systems.

____ 4. Sensors are often located in fuel filters to detect fuel blockage problems.

____ 5. In cold temperatures (under 20°F) number 2 diesel should be used.

____ 6. The injection pump is usually gear driven by the crankshaft.

____ 7. The diesel fuel injection nozzle is opened by a signal from the ECM.

____ 8. Diesel is injected directly into the combustion chamber.

____ 9. The injector pump is lubricated as fuel passes through it.

____ 10. Some seepage is normal for fuel injector operation.

SECTION B. **Select the best answer from the five choices listed.**

____ 11. If diesel fuel delivery to each cylinder is not equal,

a. all cylinders will fail to reach maximum power.
b. the engine will run rough.
c. the engine will lose power.
d. the engine may not accelerate properly.
e. all the above will occur.

____ 12. A diesel engine uses

a. spark plugs.
b. an ignition coil.
c. a distributor.
d. an electronic ignition.
e. none of the above.

____ 13. Cold temperatures cause diesel fuel to

a. freeze.
b. separate into gasoline and kerosene.
c. create wax flakes.
d. become excessively thick.
e. do none of the above.

____ 14. The diesel injection valve opens on command from

a. the ECM.
b. the fuel distributor.
c. the O_2 sensor.
d. the distributor timing impulse.
e. none of the above.

____ 15. Actual combustion in diesel engines begins in

a. the precombustion chamber.
b. the combustion chamber.
c. the injector tip.
d. the injector pump.
e. none of the above.

(NOTE: The student must obtain a minimum score of _____ on Part I of the Unit V Test in order to receive an evaluation for Competencies K2, K5, and K6.)

PART II. INSPECTING AND REPAIRING DIESEL FUEL SYSTEMS

SECTION A. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 16. When replacing a spin-on diesel fuel filter, turn the filter one turn after the gasket contacts the adaptor base.

____ 17. Trapped air in a diesel fuel filter will cause the tail pipe to emit black smoke.

____ 18. A diesel starter should be energized for not more than 10 seconds.

____ 19. After changing a diesel fuel filter, purge the system of air.

____ 20. Some diesel fuel systems automatically purge themselves of air.

(NOTE: The student must obtain a minimum score of _____ on Part II of the Unit V Test in order to receive an evaluation for Competency K2.)

PART III. DISASSEMBLING, CLEANING, AND INSPECTING DIESEL FUEL SYSTEMS

SECTION A. Read each of the below statements made by Technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.

____ 21. TECHNICIAN I says that only lines capable of holding high pressure should be used as injector lines.

TECHNICIAN II says that, when changing diesel injector nozzles, always change the copper sealing washer.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 22. TECHNICIAN I says that problematic injector nozzles on diesel engines can cause black exhaust and a loss of power.

TECHNICIAN II says that malfunctioning injector nozzles on diesel engines can cause misfiring, decreased fuel economy and overheating.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 23. TECHNICIAN I says that defective diesel injector nozzles are located with a VOM.

TECHNICIAN II says that diesel fuel is run through the diesel injector while it is tested.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 24. TECHNICIAN I says that a diesel injector should be tested to determine if it opens at the correct pressure.

TECHNICIAN II says that a diesel injector should be tested to determine if it leaks under pressure.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 25. TECHNICIAN I says that, when testing diesel injector spray patterns, the pattern should be in a wide V shape with finely atomized droplets.

TECHNICIAN II says that all injectors should chatter at some point during the chatter test.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 26. TECHNICIAN I says that diesel injectors can be taken apart and cleaned.

TECHNICIAN II says that diesel injectors can be destroyed by taking them apart.

(NOTE: The student must obtain a minimum score of _____ on Part III of the Unit V Test in order to receive an evaluation for Competency K5.)

PART IV. REPAIRING AND REPLACING DIESEL FUEL INJECTION SYSTEMS

SECTION A. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 27. The air cross over must usually be removed to remove a diesel injection pump.

____ 28. Two wrenches should be used when removing injection pump lines to the injectors.

____ 29. To install the injection pump correctly, the number 1 cylinder should be in a position ready to fire.

____ 30. Static or dynamic timing can be used to time diesel fuel injectors.

____ 31. Never run a diesel engine with a loose injector pump.

SECTION B. **Read each of the below statements made by Technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.**

____ 32. TECHNICIAN I says that diesels are timed with a conventional timing light.

TECHNICIAN II says that during timing of a diesel engine, one glow plug is removed if a timing meter is used.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 33. TECHNICIAN I says that the higher the octane rating of the diesel, the better its quality.

TECHNICIAN II says that, when timing a diesel engine, the octane of the fuel must be taken into account.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 34. TECHNICIAN I says that, when removing the injector pump, the fuel filter is often removed.

TECHNICIAN II says always to bleed the fuel lines before trying to start the diesel engine after an injector pump repair.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

(NOTE: The student must obtain a minimum score of _____ on Part IV of the Unit V Test in order to receive an evaluation for Competency K6.)

ANSWERS TO UNIT V TEST

1. t
2. t
3. t
4. f
5. f
6. f
7. f
8. f
9. t
10. f
11. d
12. e
13. c
14. e
15. a
16. f
17. f
18. t
19. t
20. t
21. b
22. c
23. d
24. c
25. b
26. a
27. t
28. t
29. t
30. t
31. t
32. b
33. d
34. c

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT VI: EXHAUST SYSTEMS AND TURBOCHARGERS

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the various exhaust systems and turbocharger components and explain their operation. The student should also be able to replace exhaust system components and diagnose and repair turbocharger systems. The student will demonstrate mastery of the material by achieving a score of ______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the components of an automotive exhaust system (Competency K8, Unit VI Test).

II. Identify the function of the various exhaust system components (Competency K8, Unit VI Test).

III. Identify the procedures for repairing and replacing exhaust system components (Competency K8, Unit VI Test).

IV. Demonstrate the ability to:

  a. Inspect exhaust system components (Competency K8, JS1-L1-UVI).

  b. Replace exhaust system components (Competency K8, JS2-L1-UVI).

  c. Remove and install exhaust manifolds (Competency K8, JS3-L1-UVI).

Lesson 2.

I. Identify the components of a turbocharger (Competency K1, Unit VI Test).

II. Identify the principles of operation of an exhaust-driven turbocharger (Competency K1, Unit VI Test).

III. Identify methods for lubricating and cooling a turbocharger (Competency K1, Unit VI Test).

IV. Identify the operation of an intercooler (Competency K1, Unit VI Test).

V. Identify the operation of a boost gauge (Competency K1, Unit VI Test).

Lesson 3.

I. Identify the procedures for diagnosing turbocharger operation (Competency K1, Unit VI Test).

II. Identify the procedure for replacing a turbocharger (Competency K1, Unit VI Test).

III. Demonstrate the ability to:

  a. Test a turbocharger (Competency K1, JS1-L3-UVI).

  b. Remove and replace a turbocharger (Competency K1, JS2-L3-UVI).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks H048 and H060.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT VI: EXHAUST SYSTEMS AND TURBOCHARGERS

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      AS2-L1-UVI: Procedure for Removing and Installing the Exhaust Manifold

   c. Job sheets

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      JS2-L1-UVI: Replacing Exhaust System Components
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2. Lesson 2: TURBOCHARGER COMPONENTS AND OPERATION

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      JS1-L3-UVI: Performing a Test of Turbocharger
      JS2-L3-UVI: Removing and Replacing a Turbocharger

E. Unit test

F. Answers to unit test

REFERENCES

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Chrysler Corporation. Technical Guide, 3.7/5.2 Liter Engine Performance. 1982.

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General Motors Corporation. 1969 Buick Chassis Service Manual. 1968.

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General Motors Corporation. Engine Performance Testing. 1987.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L2-UVI before taking the Unit VI Test. Students should do AS1-L1-UVI in conjunction with JS2-L1-UVI; AS2-L1-UVI in conjunction with JS3-L1-UVI; and AS1-L3-UVI in conjunction with JS2-L3-UVI.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT VI: EXHAUST SYSTEMS AND TURBOCHARGERS

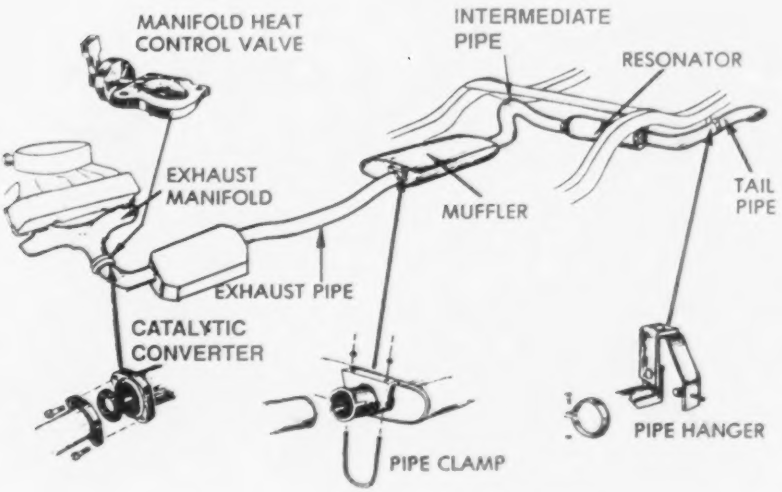
LESSON 1: EXHAUST SYSTEMS

I. Introduction to exhaust systems and turbochargers

A. The exhaust system directs the spent exhaust gases from the engine and safely carries the gases away from the passenger compartment. The exhaust system reduces engine exhaust noise to an acceptable level. The exhaust system of modern automobiles also helps to control the level of exhaust emissions.

B. Components of the exhaust system

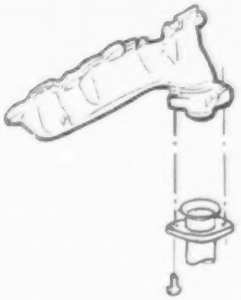
1. Exhaust manifold
2. Exhaust pipe
3. Catalytic converter
4. Muffler
5. Resonator
6. Intermediate pipe
7. Tail pipe
8. Hangers, gaskets, clamps


MANIFOLD HEAT CONTROL VALVE
INTERMEDIATE PIPE
RESONATOR
EXHAUST MANIFOLD
TAIL PIPE
MUFFLER
EXHAUST PIPE
CATALYTIC CONVERTER
PIPE HANGER
PIPE CLAMP

II. Description of exhaust system components

A. Exhaust manifold

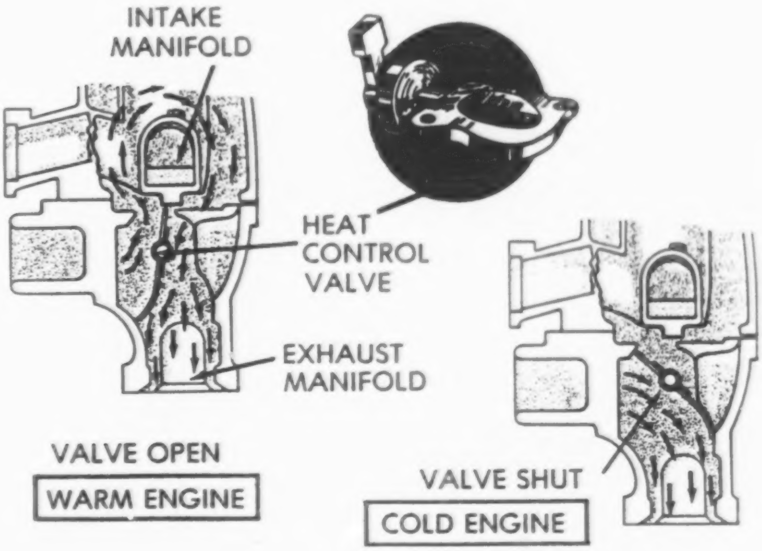
1. The exhaust manifold consists of a group of interconnected pipes that deliver the exhaust gases from the exhaust ports of the cylinder head to the exhaust pipe.



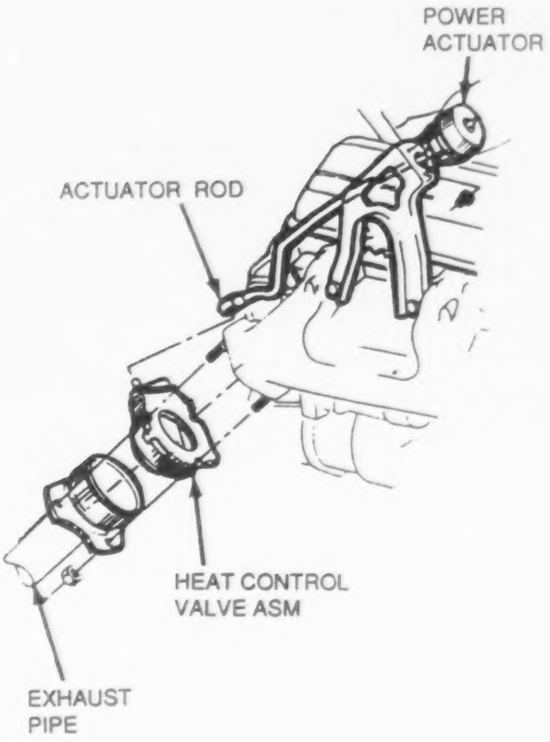
2. Exhaust pipes have traditionally been made of cast iron. Some newer vehicles have manifolds constructed of welded steel tubing, however.

3. The exhaust manifold commonly has a heat control valve that is used to redirect exhaust gases under the carburetor during cold engine operation. This aids in fuel vaporization.

   a. The heat control valve may be operated by a thermostatic spring.


INTAKE MANIFOLD
HEAT CONTROL VALVE
EXHAUST MANIFOLD
VALVE OPEN
WARM ENGINE
VALVE SHUT
COLD ENGINE

b. Many newer designs use a vacuum-operated heat control valve. An engine coolant sensor controls the flow of vacuum to a vacuum actuator, which controls the manifold heat control valve.



4. The exhaust manifold is bolted to the cylinder head. Sealing between the cylinder head and manifold may or may not use a gasket, depending on design.

B. The exhaust pipe connects to the exhaust manifold and directs the spent exhaust gases rearward. The exhaust pipe may be constructed of welded steel tubing or stainless steel. Stainless steel is not susceptible to rusting as are steel pipes. The exhaust pipe is bolted to the exhaust manifold. This connection may or may not use a gasket, depending on design. Some applications use a flared end on the pipe.

(NOTE: In many applications, the exhaust pipe is allowed to pivot on the manifold in accordance with engine torque movement.)

C. The muffler reduces exhaust noise while still allowing the exhaust to flow freely from the engine. The muffler is commonly constructed of a series of baffles, chambers, and tubes that break up and silence exhaust noise. (The noise results from pressure created each time an exhaust valve opens.) Mufflers may be made of steel, aluminized steel, or stainless steel.

D. The resonator is a "second" muffler used on some cars to reduce exhaust noise further. The resonator may be located either ahead of or behind the muffler.

E. On some vehicles, an intermediate pipe fits between the exhaust pipe and the muffler. The tail pipe is located at the rear of the vehicle and carries the exhaust gases from the muffler to the rear of the car.

F. The catalytic converter reduces exhaust emissions. The catalytic converter will be discussed in detail in the Emissions Section of this module.

G. Clamps, hangers, and heat shields

1. Many pipe connections consist of one pipe sliding inside or over another pipe. Clamps are used to hold the connections securely and to ensure a tight seal.

2. Hangers are used to support the weight of the exhaust system. Hangers usually have rubber insulators to prevent noise and vibration from the exhaust system from being transferred into the vehicle.

3. Heat shields are sometimes used to protect underbody components and any objects under the vehicle from hot exhaust components.

III. Repairing and replacing the exhaust system

A. Exhaust manifold

1. Procedure for inspecting the exhaust manifold before removal

a. Inspect the manifold for cracks and leakage. Leakage is usually evidenced by black carbon deposits around the source of the leakage.

b. Start the engine and listen for exhaust leakage. Leakage at the manifold generally makes a sharp ticking sound.

c. Check for loose manifold to cylinder head bolts. If loose bolts are found, tighten to specified torque.

2. Procedure for removing the exhaust manifold

a. Remove bolts attaching exhaust pipe to the manifold.

b. Remove bolts attaching the manifold to the cylinder head and remove the manifold.

3. Procedure for cleaning and inspecting the exhaust manifold

a. Clean the mating surfaces on the cylinder head and manifold., wash with solvent and blow dry with compressed air. Inspect manifold for cracks.

b. Inspect the mating surface of the manifold for flatness with a straightedge. Compare results to specifications.

4. Procedure for installing the exhaust manifold

a. Install manifold in reverse order of disassembly.

b. Tighten all fasteners to specified torque and in the sequence designated in the service manual.

c. Start engine and check for exhaust leakage.

B. Replacing the muffler and pipe

1. Procedure for inspecting the muffler and pipe before replacement

a. Raise and secure the vehicle on a hoist.

b. Inspect condition of mufflers and pipes. Mufflers or pipes with holes or large dents or kinks, which would restrict exhaust flow, should be replaced.

(NOTE: The technician can expect to find a small hole drilled in the end of the muffler by the manufacturer. This hole allows for condensation drainage.)

c. Inspect condition of hangers. All hangers should be in good condition. Wire is not an acceptable substitute for a hanger.

d. Inspect exhaust routing. Pipes should not be contacting the undercarriage at any point. Exhaust should never be routed through the passenger compartment.

e. Inspect the manifold heat control valve. It should work freely with no binding or sticking.

f. With the engine running, check for exhaust leaks at all points along the exhaust system. No leakage should be noted (with the exception of the drain hole discussed above.)

2. Procedure for replacing mufflers and pipes

(NOTE: Procedures for replacing mufflers, exhaust pipes, tail pipes, etc. are very similar. The following example is for replacement of a muffler.)

a. Raise the vehicle on a hoist. The rear axle should lower to the full extent of its travel.

b. Remove the clamp from the exhaust pipe to the muffler connection.

c. Remove the clamp from the tail pipe to the muffler connection.

d. Remove the tail pipe rear hanger and remove the tail pipe from the muffler. Move the tail pipe out of the way.

e. Remove the muffler from the exhaust pipe and discard the muffler.

f. Install the new muffler in reverse order of disassembly.

g. Align all components and tighten clamps and hangers to specified torque.

h. Start vehicle and check system for leaks.

i. Lower vehicle.

(NOTE: The use of heat or special muffler chisels may be required to separate rusted exhaust system components. Also some systems require that the parts be welded together during assembly. Consult the appropriate service manual for specific instructions.)

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR EXHAUST COMPONENT REPLACEMENT

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, engine size, and year of the vehicle to be serviced.
2. Develop a written procedure for removing the exhaust component to be replaced.
3. Develop a written procedure for installation of the exhaust component.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR REMOVING AND INSTALLING THE EXHAUST MANIFOLD

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, engine size, and year of the vehicle to be serviced.
2. Develop a written procedure for removing the exhaust manifold.
3. Develop a written procedure for inspecting the exhaust manifold. Include procedure for checking manifold for warpage.
4. Develop a written procedure for installing the exhaust manifold. Determine and record manifold fastener torque and tightening sequence.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

INSPECTING EXHAUST SYSTEM COMPONENTS

Equipment:

Serviceable vehicle
Hoist
Safety glasses

Procedure:

		Evaluation 3 2 1 N
1.	Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2.	Place the vehicle securely on safety stands or lift with hoist.	__ __ __ __
3.	Inspect the condition of the exhaust system and record the results below.	__ __ __ __

a. Exhaust pipe

OK____ NOT OK____

b. Muffler

OK____ NOT OK____

c. Catalytic converter

OK____ NOT OK____

d. Intermediate pipe

OK____ NOT OK____

e. Resonator

OK____ NOT OK____

f. Tail pipe

OK____ NOT OK____

g. Hangers

OK____ NOT OK____

h. Clamps

OK____ NOT OK____

i. Heat shields

OK____ NOT OK____

j. Exhaust manifolds

OK____ NOT OK____

k. Manifold heat control valve

OK____ NOT OK____

4. For any of the above items marked "NOT OK", describe the problem and explain what should be done to correct it. _ _ _ _

5. Connect exhaust ventilation equipment, start vehicle and check for exhaust leaks. Note any leaks found. Based on the inspections, describe the condition of the vehicle. _ _ _ _

(**CAUTION:** Be sure to use approved exhaust ventilation equipment when operating a vehicle in an enclosed area.)

6. Shut engine off, disconnect exhaust ventilation equipment, and lower vehicle. _ _ _ _

*Average of above evaluations _ _ _ _

(*This average is a partial evaluation for Competency K8. Final evaluation for K8 will be made at the end of JS3-L1-UVI.)

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

REPLACING EXHAUST SYSTEM COMPONENTS

Equipment:

Hand tools
Hoist
Serviceable vehicle
Special tools as outlined in assignment sheet
Safety glasses

Procedure:

		Evaluation 3	2	1	N
1.	Wear safety glasses while doing all procedures on this job sheet.	___	___	___	___
2.	Place the vehicle securely on safety stands or lift with hoist.	___	___	___	___
3.	Complete AS1-L1-UVI. Following the procedure developed in item 2 of AS1-L1-UVI, remove the defective exhaust system component.	___	___	___	___
4.	Inspect the condition of all hangers, heat shields, and all other components. Record observations.	___	___	___	___
5.	Following the procedure developed in item 3 of AS1-L1-UVI, install the exhaust system component(s). (NOTE: Replace all defective hangers, heat shields, clamps, and other parts as directed by the instructor.) (NOTE: Inspect exhaust system for proper alignment. Make sure no components are misaligned and contacting the vehicle frame or body.)	___	___	___	___
6.	Connect exhaust ventilation equipment, start vehicle and check for exhaust leakage. Correct any leakage found.	___	___	___	___
7.	Shut off vehicle, disconnect exhaust ventilation equipment, and lower vehicle.	___	___	___	___
	*Average of above evaluations	___	___	___	___

(*This average is a partial evaluation for Competency K8. Final evaluation for K8 will be made at the end of JS3-L1-UVI.)

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

REMOVING AND INSTALLING AN EXHAUST MANIFOLD

Equipment:

Hand tools
Serviceable vehicle
Hoist
Special tools as outlined in assignment sheet
Safety glasses

Procedure:	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2. Complete AS2-L1-UVI. Following the procedures developed in item 2, remove the exhaust manifold.	__ __ __ __
3. Following the procedure developed in item 3 of AS2-L1-UVI, clean and inspect the exhaust manifold. Record results of the inspection below.	__ __ __ __
Manifold cracked YES_____ NO_____	
Manifold warped YES_____ NO____	
4. Following the procedure developed in item 4 of AS2-L1-UVI, install the exhaust manifold. Tighten all fasteners to specified torque and in the proper sequence.	__ __ __ __
5. Connect exhaust ventilation equipment, start vehicle and inspect for leakage.	__ __ __ __
(**CAUTION:** Be sure to use approved exhaust ventilation equipment when operating a vehicle in an enclosed area.)	
6. Shut off vehicle and disconnect exhaust ventilation equipment.	__ __ __ __
*Average of above evaluations	__ __ __ __

(*This average is a partial evaluation for Competency K8. Final evaluation for K8 will be made at the end of this job sheet.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency K8 by averaging the evaluations of JS1-L1-UVI, JS2-L1-UVI, and JS3-L1-UVI. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS1-L1-UVI	__	__	__	__
JS2-L1-UVI	__	__	__	__
JS3-L1-UVI	__	__	__	__
Final evaluation for Competency K8	__	__	__	__

MODULE: ENGINE PERFORMANCE

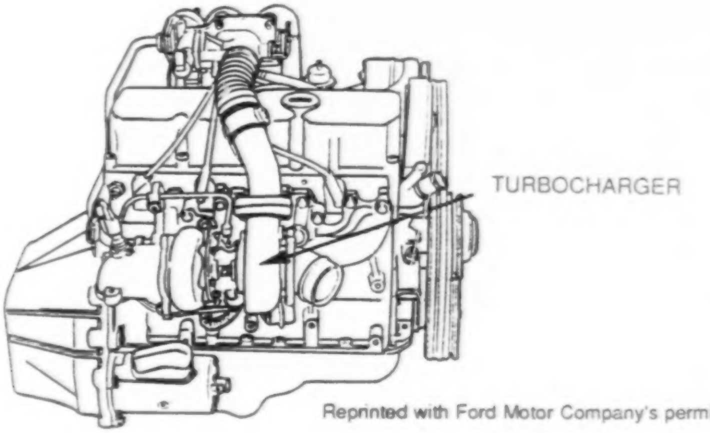
(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT VI: EXHAUST SYSTEMS AND TURBOCHARGERS

LESSON 2: TURBOCHARGER COMPONENTS AND OPERATION

I. Description of turbocharger

A. A turbocharger is a device that is driven off engine exhaust. The turbocharger enables an engine to consume a denser mixture of air and fuel. This dense mixture increases horsepower and torque (on demand) in comparison with non-turbocharged engines of the same size (displacement). The turbocharger also increases fuel economy over larger displacement engines that have comparable horsepower.



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B. Components of the turbocharger include the turbine, the compressor, the center housing, the outlet elbow, the actuator

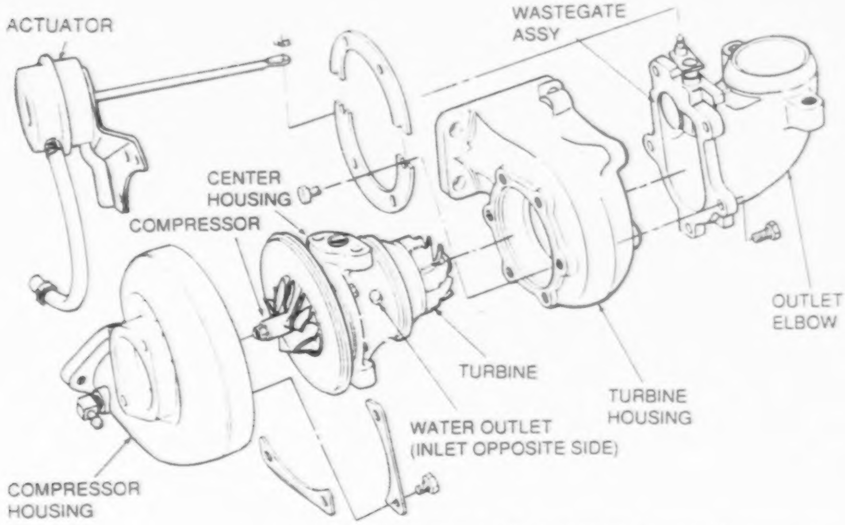
1. The turbine is a wheel that is powered by exhaust flow. The turbine drives the compressor. Exhaust from the exhaust manifold flows into the turbine. The turbine wheel is enclosed in the turbine housing.

2. The compressor is the wheel driven by the turbine. The compressor is attached to the turbine through a steel shaft. The compressor wheel is enclosed in the compressor housing.

3. The center housing supports the bearings, shaft, turbine, and compressor. Oil passages connect the center housing bearings to the engine oiling system. Most turbo designs incorporate a water passage in the center housing for cooling. Engine coolant flows through this passage.

4. The outlet elbow houses the waste-gate. The waste-gate is a valve that allows a portion of exhaust gas to be by-passed directly to the exhaust system when intake pressure becomes too high.

5. The actuator is a spring-loaded diaphragm that senses pressure from the compressor outlet. The actuator opens the waste-gate when pressure exceeds a preset limit.


ACTUATOR
WASTEGATE ASSY
CENTER HOUSING
COMPRESSOR
OUTLET ELBOW
TURBINE
TURBINE HOUSING
WATER OUTLET (INLET OPPOSITE SIDE)
COMPRESSOR HOUSING

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II. Operation

A. As the engine runs, exhaust gases are directed to the turbine wheel.

1. As engine speed increases, the turbo starts to spin faster.

2. Because the compressor is attached to the same shaft as the turbine, it also rotates at the same speed.

3. As the compressor turns faster, more vacuum is created, drawing more air into the compressor housing through the air filter.

4. The air is then forced out of the compressor at an elevated pressure and temperature and into the engine induction system.

5. The result is a denser air/fuel mixture being forced into the cylinder.

6. The denser air/fuel mixture results in greater power output and is referred to as "boost."

B. Boost can increase to a point where engine damage will result. To prevent damage a waste-gate is used.

1. Normal boost pressure is from 7 to 12 psi, depending on manufacturer's design.

2. The waste-gate is a relief valve that is located in the outlet elbow.

3. When boost reaches a predetermined point, the waste-gate opens and the exhaust by-passes the turbine. This reduces turbo speed and lowers boost pressure.

4. The waste-gate is controlled by the waste-gate actuator.

   a. A metal rod connects the actuator to the waste-gate valve.

   b. The actuator consists of a spring-loaded diaphragm, which is exposed to compressor pressure.

   c. When compressor pressure reaches the preset spring limit, the pressure overcomes spring tension by pushing against the diaphragm.

   d. This moves the actuating rod and opens the waste-gate.

   e. As pressure drops, spring pressure once again forces the waste-gate door closed.

5. Some turbocharged engines that have electronic engine controls incorporate a solenoid that prevents the waste-gate from closing until the engine reaches operating temperature. This prevents damage to the engine and turbocharger during cold operation.

III. Turbocharger lubrication and cooling

A. Lubrication

1. The turbo is capable of operating at speeds of 120,000 rpm or greater. The turbo is also subjected to the high temperatures of the exhaust system. Engine oil is directed to the turbocharger center housing to lubricate and cool the bearing.

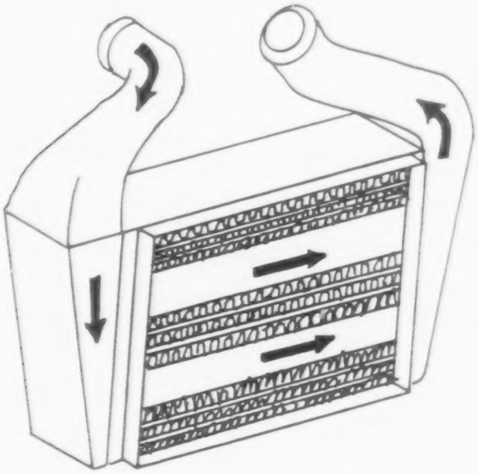
2. When changing oil on a turbocharged engine, use only oil that the manufacturer has approved for turbocharged engines. Also, change oil and filter at recommended intervals. Oil seals on the shaft prevent oil from leaking into either the compressor or turbine housing.

B. During full throttle boost, exhaust gas temperatures can exceed 1800 degrees Fahrenheit. Most newer turbocharger designs incorporate an engine coolant passage to help cool the turbo and prolong its life. Many early turbo failures were a result of overheated oil.

IV. Intercooler

A. The intercooler is a device that resembles a small radiator and is used to cool the compressed air charge before it reaches the engine induction system. The intercooler may be either an air-to-air intercooler or an air-to-water intercooler.

B. The intercooler is located between the turbo compressor outlet and the carburetor/throttle body inlet. Cooling of the air charge makes it more dense, which results in even more power output. Also the cooler air charge is less likely to cause pre-ignition.



V. Boost gauge

A. Some vehicles use a boost gauge. The boost gauge is a vacuum/pressure gauge that registers intake manifold pressure.

B. The boost gauge indicates when the vehicle is achieving "turbo boost." Vehicles without a turbo boost gauge have a light that comes on when "turbo boost" is achieved.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

TURBOCHARGER COMPONENTS AND OPERATION

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. What drives a turbocharger?

2. List the five major turbocharger components.

3. What component limits the maximum boost attained by the turbocharger?

4. What component resembles a small radiator and is used to cool the air compressed by the turbocharger?

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

TURBOCHARGER COMPONENTS AND OPERATION

(ANSWER SHEET)

1. Exhaust
2. Turbine, actuator, compressor, outlet elbow, center housing
3. Waste-gate
4. Intercooler

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT VI: EXHAUST SYSTEMS AND TURBOCHARGERS

LESSON 3: TURBOCHARGER DIAGNOSIS AND REPLACEMENT

I. Diagnosing the turbocharger

  A. Procedures for inspecting the turbocharger

    1. Inspect engine oil level. Oil level is critical to the safe and proper operation of turbocharged engines. Use only oil that has been approved by the vehicle manufacturers for use in their turbocharged engines.

    2. Inspect the air filter. A dirty air filter can reduce engine performance and create an overly rich fuel mixture. A badly clogged air filter can create a high vacuum in the compressor housing. If the vacuum becomes high enough, it can draw oil past the turbo shaft seal.

    3. Inspect plumbing between the air filter and compressor housing. If the hose is leaking, unfiltered air will bypass the air filter and be drawn into the compressor housing and engine. The result could be premature wear and failure of the turbo housing.

    4. Inspect plumbing between compressor housing and the carburetor/throttle body. A leak in this hose can cause noise during engine operation and a reduction in boost.

    5. Check for exhaust leakage. Leakage between the exhaust manifold and turbine inlet can result in a loss of power due to a lack of boost. Leakage between the exhaust manifold and engine also will result in a loss of power. Make sure all fasteners are tight and set to proper torque.

  B. Procedures for inspecting the waste-gate operation

    1. Inspect the condition of the hose leading to the waste-gate actuator. Replace hose if broken, collapsed or deteriorated.

    2. Disconnect hose to waste-gate actuator.

    3. Connect a pressure pump and gauge to the actuator.

    4. Using the pressure pump, apply pressure to the actuator. (See service manual for pressure specification--usually around 8 psi).

    5. The actuator rod should move in response to the pressure applied. (See appropriate service manual for the correct amount of rod movement.)

    6. If the actuator does not respond properly to this test, it should be replaced.

  C. Procedure for performing turbocharger boost test

    1. If the vehicle is not equipped with a boost gauge, install a vacuum/pressure gauge to the intake manifold.

2. Bring vehicle to operating temperature and operate the vehicle on a chassis dynamometer at full load.

3. Read boost gauge and compare to manufacturer's specifications.

4. If boost does not meet manufacturer's specifications, the turbocharger must be repaired or replaced.

D. Procedure for performing turbocharger boost test (alternate method)

1. Drive vehicle to an area where there is no traffic.

2. With engine at operating temperature, accelerate from 0 to about 50 miles per hour. Observe boost gauge.

3. Boost should meet manufacturer's specification.

II. Procedure for replacing the turbocharger

(**CAUTION:** Turbochargers can become extremely hot. Take precautions to prevents burns when working with turbochargers.)

(NOTE: The following is a general description of turbocharger replacement. Actual procedures will vary. Consult the appropriate service manual when working with a specific vehicle.)

A. Procedure for removing the turbocharger

1. Allow exhaust to cool to prevent burns.

2. Remove negative battery cable.

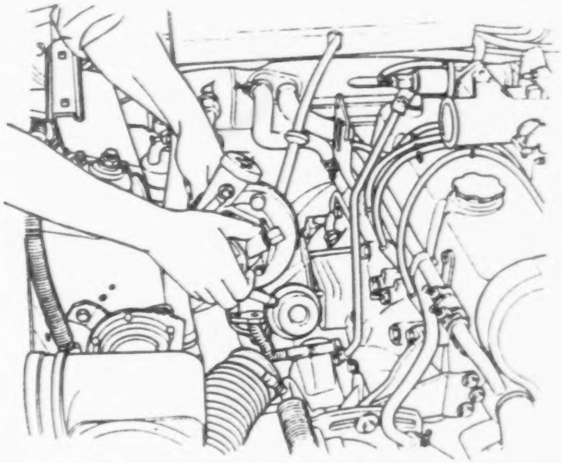
3. Drain engine coolant (water-cooled turbo).

4. Disconnect turbocharger oil supply and return lines.

5. Disconnect water inlet and outlet tubes.

6. Disconnect discharge tube to throttle body/carburetor from outlet elbow.

7. Unbolt compressor housing from engine and remove turbocharger.



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(NOTE: Portions of the turbocharger removal and installation procedures must usually be done with the car on safety stands or hoist.)

B. Procedure for inspecting the turbocharger

1. Spin compressor wheel and note any rubbing of the wheel on the housing. Also, look for signs of the wheel rubbing on the housing.
2. Move waste-gate arm to check for free movement of waste-gate. Look for proper closing of the waste-gate valve.
3. Check discharge tube to the throttle body. There should be no holes or cracks.
4. Clean turbocharger gasket surfaces on engine and turbocharger.

C. Procedure for installing the turbocharger

1. Install turbocharger in reverse order of disassembly. Install new turbo mounting gasket and any other gaskets used. Tighten all fasteners to specified torque.
2. Refill with engine coolant and reconnect battery cable.
3. Connect exhaust ventilation equipment to vehicle exhaust and start engine.
4. Bring engine to operating temperature. Top off coolant level.
5. Check for proper turbocharger operation following boost test procedure outlined earlier in this lesson.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PROCEDURE FOR REMOVING AND INSTALLING A TURBOCHARGER

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, engine size, and year of the vehicle to be serviced.
2. Develop a written procedure for removing the turbocharger.
3. Develop a written procedure for installing the turbocharger. Determine and record all torque specifications related to turbocharger installation.

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

PERFORMING A TEST OF TURBOCHARGER

Equipment:

Serviceable vehicle
Hoist
Boost gauge
Safety glasses

Procedure:

			Evaluation 3 2 1 N
1.	Wear safety glasses while doing all procedures on this job sheet.		__ __ __ __
2.	Visually inspect the items listed below and record the results in the spaces provided.		__ __ __ __

a. Engine oil OK_____ NOT OK_____

b. Air filter OK_____ NOT OK_____

c. Air ducting OK_____ NOT OK_____

3. Connect exhaust ventilation equipment to the vehicle and start engine. Check for exhaust leakage between the turbocharger and manifold and between the exhaust manifold and engine. Record results below. __ __ __ __

4. Following the procedure outlined below, check waste-gate operation. __ __ __ __

a. Inspect condition of waste-gate actuator hose.

OK_____ NOT OK_____

b. Test waste-gate operation.

Pressure required to activate waste-gate (See applicable service manual.)

Pressure_______________

c. Does actuator respond to pressure applied?

YES_____ NO_____

5. Following the procedure outlined below, perform turbocharger boost test. __ __ __ __

   a. Determine and record maximum boost for the vehicle being testing.

      Boost__________psi

   b. If vehicle is not equipped with a boost gauge, connect a gauge to the engine.

   c. Check the appropriate blank to indicate whether a dynamometer or road test is being used to check boost.

      Dynamometer________

      Road test__________

   d. After obtaining permission from the instructor, perform a boost test and record the results in the space provided below.

      Boost pressure______________

6. Based on the tests performed, describe the condition of the turbocharger below. __ __ __ __

*Average of above evaluations __ __ __ __

(*This average is a partial evaluation for Competency K1. Final evaluation for K1 will be made at the end of JS2-L3-UVI.)

JS2-L3-UVI

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

REMOVING AND REPLACING A TURBOCHARGER

Equipment:

Hand tools
Serviceable vehicle
Special tools as outlined in assignment sheet
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

   (**CAUTION:** Turbochargers can become extremely hot. Take precautions to prevents burns when working with turbochargers.)

2. Complete AS1-L3-UVI. Following the procedure developed in AS1-L3-UVI, remove the turbocharger from the vehicle. ___ ___ ___ ___

3. Inspection the turbo charger. Answer the questions below. ___ ___ ___ ___

   a. Does the turbine wheel rub on the housing?

      YES____ NO____

   b. Does the waste-gate work freely and close properly?

      YES____ NO____

   c. Are the inlet and discharge ducts working properly?

      OK____ NOT OK____

4. Clean turbocharger gasket surfaces on engine and turbocharger. ___ ___ ___ ___

5. Following the procedure developed in AS1-L3-UVI, install the turbocharger. Tighten all fasteners to specified torque ___ ___ ___ ___

6. Connect exhaust ventilation equipment to vehicle, start the engine and bring it to the operating temperature. ___ ___ ___ ___

7. Inspect for exhaust leakage and correct if found. Top off coolant level. ___ ___ ___ ___

8. After obtaining permission from the instructor, test turbocharger operation by performing a "boost test" as outlined in JS1-L3-UVI. Record results in the space provided below. ___ ___ ___ ___

*Average of above evaluations ___ ___ ___ ___

(*This average is a partial evaluation for Competency K1. Final evaluation for K1 will be made below.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency K1 by averaging the evaluations of JS1-L1-UIII, JS1-L2-UIV, JS1-L3-UVI, and JS2-L3-UVI. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS1-L1-UIII	___	___	___	___
JS1-L2-UIV	___	___	___	___
JS1-L3-UVI	___	___	___	___
JS2-L3-UVI	___	___	___	___
Final evaluation for Competency K1	___	___	___	___

MODULE: ENGINE PERFORMANCE

(SECTION B: FUEL AND EXHAUST SYSTEMS)

UNIT VI: EXHAUST SYSTEMS AND TURBOCHARGERS

UNIT VI TEST

PART I. TURBOCHARGERS

SECTION A. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 1. Stainless steel is not susceptible to rust.

____ 2. Exhaust pipes sometimes pivot at the exhaust manifold.

____ 3. A resonator may be located ahead or behind the muffler.

____ 4. Exhaust hangers prevent exhaust noise and vibration from being transferred into the passenger compartment.

____ 5. Turbochargers increase horsepower and torque on demand.

____ 6. An intercooler is used to cool the turbocharger.

____ 7. On some turbocharged vehicles, the waste-gate will not close until the engine is warm.

____ 8. The turbocharger can turn at over 120,000 rpm in extremely high temperatures.

SECTION B. Select the best answer from the five choices listed.

____ 9. The exhaust system does not

a. direct exhaust gases away from the passenger compartment.
b. help to control exhaust emissions.
c. reduce vehicle noise level.
d. drive the supercharger.
e. release emissions into the atmosphere.

____ 10. The catalytic converter works to

a. reduce vehicle noise level.
b. increase back pressure.
c. lower emissions.
d. lower back pressure.
e. do none of the above.

____ 11. In a turbocharger, exhaust gases drive

a. the waste-gate.
b. the turbine.
c. the compressor.
d. the actuator.
e. none of the above.

____ 12. When the turbo charger waste-gate opens,

a. intake manifold boost increases.
b. horsepower and toque are increased.
c. some exhaust gases are diverted around the turbo.
d. all of the exhaust gases are diverted around the turbo.
e. none of the above happens.

____ 13. If turbo boost becomes too high,

a. too much power will be created for the power train.
b. vehicle speed becomes dangerously high.
c. the turbo charger will explode.
d. the engine will be damaged.
e. all the above may happen.

SECTION C. **Read each of the below statements made by Technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.**

____ 14. TECHNICIAN I says that exhaust manifolds have been traditionally cast of aluminum.

TECHNICIAN II says that some exhaust manifolds are made from welded steel tubing.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 15. TECHNICIAN I says that carburetor-equipped vehicles use a heat control valve on one exhaust manifold.

TECHNICIAN II says that the heat control valve used on newer vehicles is opened by a heat-sensitive spring.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 16. TECHNICIAN I says that the meeting surface between the exhaust manifold and the cylinder head may or may not use a gasket.

TECHNICIAN II says that some new vehicles use stainless steel exhaust pipes.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 17. TECHNICIAN I says that the turbocharger is driven by exhaust gases.

TECHNICIAN II says that the turbocharger increases fuel economy in large displacement engines.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 18. TECHNICIAN I says that the turbocharger turbine and compressor are connected by a steel shaft.

TECHNICIAN II says that the center housing contains connections to the fuel, lubrication, and cooling systems.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 19. TECHNICIAN I says that the turbocharger provides the engine with a denser and hotter air/fuel mixture than that of nonturbocharged vehicles.

TECHNICIAN II says that the normal boost pressures are from 15 to 20 pounds.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 20. TECHNICIAN I says that failures in early turbocharger systems often resulted from overheated oil.

TECHNICIAN II says that intercoolers can eliminate the problem of overheated oil.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

(NOTE: The student must obtain a minimum score of _____ on Part I of the Unit VI Test in order to receive an evaluation for Competency K1.)

PART II. TURBOCHARGER SERVICE

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 21. On a turbocharged engine, a badly clogged air filter can result in oil burning.

____ 22. The waste-gate is activated by a vacuum-sensitive actuator.

____ 23. A turbocharger boost test must be performed by using a vacuum/pressure gauge.

____ 24. A turbocharger boost test is often performed after turbocharger repair.

____ 25. Gaskets are not normally found between the turbocharger and engine.

____ 26. Turbocharger replacement involves the removal and replacement of oil supply and return lines.

SECTION B. **Read each of the below statements made by Technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.**

____ 27. TECHNICIAN I says that oil level is critical on turbocharged engines.

TECHNICIAN II says to use only approved oils in turbocharged engines.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 28. TECHNICIAN I says that a hole in the plumbing between the air filter and the turbine can create early turbocharger wear.

TECHNICIAN II says that a hole in the plumbing between the exhaust manifold and the compressor will lower turbo boost.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

____ 29. TECHNICIAN I says that the engine should be at operating temperature during turbocharger replacement.

TECHNICIAN II says that, in some cases, the coolant will need to be drained before the turbocharger is removed.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 30. TECHNICIAN I says that, during turbocharger inspection, the compressor wheel should spin freely with no rubbing.

TECHNICIAN II says to make sure that the waste-gate operates without binding when inspecting the turbocharger

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 31. TECHNICIAN I says that a leaking exhaust manifold is identified by black carbon deposits around the source of the leak.

TECHNICIAN II says that a leaking exhaust manifold generally makes a sharp ticking sound.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 32. TECHNICIAN I says not to remove the exhaust pipe from the exhaust manifold before removing the manifold from the engine.

TECHNICIAN II says that exhaust manifolds should be checked for cracks and flatness of their mating surfaces.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 33. TECHNICIAN I says that even a small hole at the end of the muffler means that the muffler must be replaced.

TECHNICIAN II says that wire is an acceptable substitute for an exhaust hanger.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 34. TECHNICIAN I says that heat or special chisels are often needed to remove or separate exhaust components.

TECHNICIAN II says to start the vehicle and check for exhaust leaks after exhaust components have been changed.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I or II

____ 35. TECHNICIAN I says that exhaust should never be routed through the passenger compartment.

TECHNICIAN II says that the replacement procedures for mufflers, exhaust, and tail pipes are similar.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I or II

(NOTE: The student must obtain a minimum score of _____ on Part II of the Unit VI Test in order to receive an evaluation for Competency K8.)

ANSWERS TO UNIT VI TEST

1. t
2. t
3. t
4. t
5. t
6. f
7. t
8. t
9. d
10. c
11. b
12. c
13. d
14. b
15. a
16. c
17. c
18. a
19. a
20. a
21. t
22. f
23. t
24. t
25. f
26. t
27. c
28. d
29. b
30. c
31. c
32. b
33. d
34. a
35. c